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Original Articles and Clinical Cases.

PSYCHO-PHYSICAL INVESTIGATIONS WITH THE GALVANOMETER AND PNEUMOGRAPH IN NORMAL AND INSANE INDIVIDUALS.

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THESE investigations were carried out in the laboratory of the Clinic for Psychiatry at Zürich, to the director of which, Professor E. Bleuler, we are under obligations for the use of apparatus and material for study. The purposes of our

research were to ascertain the value of the so-called "psycho-physical galvanic reflex" as a recorder of psychical changes in connection with sensory and psychical stimuli; to determine its normal and pathological variations; to study the respiratory innervation curve in the same relations; and finally to compare the galvanometric and pneumographic curves taken simultaneously upon the kymograph, under the influence of various stimuli. In word-associations the reaction time was also registered for further comparison.

Chapter I.—Apparatus Employed.

For the respiratory curve we used the Marey pneumograph made by Zimmerman, in Leipzig. The kymograph was made by Schüle, in Basel, and runs with a weight, making it both steady and noiseless. The stop-watch employed for reaction time was manufactured by Billian, of Zürich.

The use of the galvanometer in experimental psychology is so new and recent as to require a special description and a brief review of the scanty literature of the subject.

The first to discover the influence of mental conditions on the galvanometer was Professor Tarchanoff, who published a paper in *Pflüger's Arch. für Physiologie*, 1890, entitled "Galvanic Phenomena in the Human Skin in Connection with Irritation of the Sensory Organs and with various Forms of Psychic Activity." He employed tubular unpolarisable clay electrodes, connected with the skin by means of hygroscopic cotton pads, 10 to 15 cm. long, saturated with saline solution. These are attached to a Meissner and Meyerstein galvanometer. Deviations of the mirror were noted through a telescope upon a scale three metres distant from the galvanometer. The scale was divided on each side of the zero point into 50 cm. and these again into mm. The galvanometer was so sensitive that a nerve stream of a frog's sciatic nerve deflected the mirror so much that all the divisions on the scale were passed over. The electrodes were applied at various times to different portions of the body, such as the hands and fingers, feet and toes, the face,

the nose, the ears and the back. Experimenting thus, he obtained the following results :—

Light tickling of the face, ears, or soles of the feet, with a camel-hair brush or a feather, induced, after a latent period of from one to three seconds, a deflection in the galvanometer to the extent of the whole 50 cm. of the scale. The same results were obtained by stimulating the skin with the faradic brush, with hot and cold water, and by pricking with a needle. Irritation in analogous ways of other sensory organs, the ear, the nose, the tongue and the eye, affected the galvanometer in a corresponding manner.

The experimenter then ascertained that actual irritation was not essential to these results, but the presentation of the proposed stimulus to the imagination also brought about similar deviations in the galvanometer. He stated, furthermore, that the recollection of some fear, fright or joy, in general any kind of strong emotion, produced the same result. The next point of interest recorded by Tarchanoff was that ordinary abstract mental exercise, such as computation, does not affect the galvanometer unless the exercise be accompanied by exertion. He also noted that the emotion of expectant attention or anticipation had a marked effect upon the galvanometer. Tarchanoff regarded the phenomena he observed as due to a secretory current of electricity associated with the sweat-glands. He was evidently unaware of the extraordinary value of the investigations he described in this brief paper. Like many discoveries of importance, his remarkable work lay buried in medical literature for years, and it was not until 1897 that any further contribution on this subject appeared. In that year, Sticker [13] records a repetition of the work of Tarchanoff. His conclusion was that the capillary system of blood-vessels was a factor in the perturbations of the galvanic current. He opposed the idea of Tarchanoff of the centripetal excitation of a secretory current, because he found that the same deviations were noted when the electrodes were applied to anæsthetic and analgesic areas of skin (functional or organic).

After the lapse of five years, Sommer [12] made some experiments with the galvanometer, but lost himself in

technical and physical details, and failed completely to grasp the intrinsically valuable features of the instrument. He observed fluctuations which he attributed to alterations in resistance of the skin or to changes in contact between skin and electrodes. He thought any apparent psychic influence due to involuntary muscular contractions induced by increased pressure on the electrodes, and concluded that, except for the reaction to tickling, no psychic influence on the galvanometer could be established with certainty. He therefore stumbled over, but missed, the one essential point.

About two years ago E. K. Müller, an electrical engineer, of Zürich, read a paper before the Swiss Society of Natural Sciences (medical section) on "The Influence of Psychic and Physiological Phenomena upon the Electrical Conductivity of the Human Body." Happening to make certain experiments upon himself in relation to the resistance of the human body in the alternating magnetic field, he rediscovered the deflectibility of the mirror-galvanometer under psychic and nervous stimulation as established by Tarchanoff.

Dr. O. Veraguth, a neurologist, of Zürich, was then led by Müller to experiment in the same direction. He made use of the Deprez-D'Arsonval mirror-galvanometer, nickel-plated brass cylinders for electrodes, a feeble electrical current, a horizontal celluloid scale on which the light from the mirror registered its movements and an apparatus for photographic delineation of the fluctuations. He published some results last August (1906) in the *Arch. de Psychologie* (Geneva), and he gave the name "psycho-physical galvanic reflex" to the phenomenon.[1] Veraguth corroborates the findings of Tarchanoff. One or two of his experiments are especially striking. If the individual under observation is read to, deviation of the mirror is noted when passages associated with emotional tone are reached. Or, if a series of unrelated words is pronounced, a test suggested to him by one of the authors of this paper (Dr. Jung), words connected with some emotional complex produce an effect on the

[1] Veraguth presented his entire results to date for discussion at the second Deutscher Congress für experimentelle Psychologie in Würtzburg in 1906, the transactions of which will be published early this year (1907).

galvanometer, while indifferent words have no effect He concludes from his studies that only such irritations as are associated with sufficiently intense and actual emotional tone induce a deviation in the galvanometer. He states in his paper that he is not yet in a position to explain the phenomenon, but that if change in resistance were the cause then there are presented manifold contradictions to our present conceptions of resistance in the human body. He did not think it due to alterations in the quantity of blood in the parts beneath the electrodes, for the phenomenon takes place whether the hands be emptied of blood by an Esmarch bandage or supercharged with blood by artificial venous stasis. Veraguth excludes the participation of the perspiration, for the results were similar in hands made dry in formalin.

As far as we know the above review covers the brief literature of the subject, but work has been carried on for about a year in this field in the laboratory of the Psychiatric Clinic at Zürich, the most of which has not yet been published. One of us (Dr. Jung) has published in the *Journal of Abnormal Psychology* (Boston), for February, 1907, the results of association experiments in which the galvanometer was employed, and in this article is a drawing of the apparatus and a description of the order of research. In the same laboratory, Dr. L. Binswanger, together with Dr. Jung, has investigated the physical and physiological problems presented by the phenomenon, the results of which will shortly be published in a separate paper, though the material conclusions of their investigations are embodied in this paper.

The apparatus employed by us is as follows: The mirror galvanometer of Deprez-D'Arsonval; a translucent celluloid scale divided into millimetres and centimetres with a lamp upon it (made by Zulauf & Co., of Zürich), the scale being placed one metre from the galvanometer; a moveable indicator sliding on the scale and connected by a device of Dr. Jung with a recording pen writing upon the kymograph; a rheostat to reduce the current when necessary; and one, sometimes two, Bunsen cells. The electrodes generally used are large copper plates, upon which the palms of the

hands rest comfortably, or upon which the soles of the feet may be placed. We have also used jars of hot water for the contact, when, as with some instances of dementia præcox, the hands were congested and cold. Occasionally we have employed a plate of zinc for one electrode and a plate of carbon for the other (in which case no element was required, since the skin, sweat and metal provided sufficient current).

Chapter II.—The Physics and Physiology of the "Psycho-physical Galvanic Reflex."

So far as has yet been determined, it would seem that the sweat glandular system is the chief factor in the production of this electric phenomenon, inducing on the one hand under the influence of nervous irritation a measurable current or, on the other hand, altering the conductivity of the current. Since water contact excludes changes induced by pressure on metal electrodes, and blanching of the fingers by the Esmarch bandage excludes changes in connection with the blood supply, both of these factors play but a small part in the deviations of the galvanometer. Change in resistance is brought about either by saturation of the epidermis with sweat, or by simple filling of the sweat-gland canals or perhaps also by intracellular stimulation; or all of these factors may be associated. The path for the centrifugal stimulation in the sweat-gland system would seem to lie in the sympathetic nervous system. These conclusions are based upon facts at present to hand and are by no means felt to be conclusive. On the contrary, there are features presented which are as yet quite inexplicable,[1] as, for instance, the gradual diminution of the current in long experiments to almost complete extinction, when our ordinary experience teaches that resistance should be much reduced and the passing current larger and stronger. This may possibly be due to gradual cooling of the skin in contact

[1] On one occasion with three persons in the circuit and one Bunsen cell, the sudden fall of a weight with loud noise caused a deflection of two centimetres.

with the cold copper plates. This can be obviated by warm water contact or by resting the copper plates upon warm sand bags. Yet there is still an inviting field for investigation here.

§ 1.—*Fluctuations of the Galvanometer from Physical Causes.*

If, when the hands are placed upon the copper-plate electrodes, they be pressed down more firmly, there is a slowly-increasing deviation of the galvanometer, but only to a minor degree. If the area of contact be diminished by the raising of the fingers or by lifting of the palms, there is a sudden diminution in the amount of current, marked by sudden reduction of amplitude in the excursion of the light.

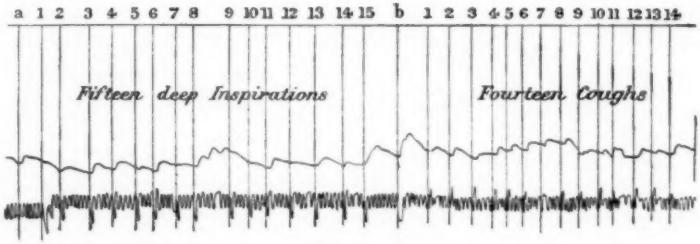

FIG. 1.

Curve to show effects of deep inspirations and coughing upon the galvanometer.[1]

A deep inspiration alone, or a deep expiration, without alteration in the contact of the hands, increases the deflection of the galvanometer, while ordinary respiratory movements do not affect it. Coughing also causes a considerable rise in the galvanometric wave. We are inclined to think that this rise in inspiration and expiration, and with coughing, may also be psychic, that is, emotional. Certainly in the curve we observe exhaustion by repetition of the command to cough or breathe deeply, as in the case of other analogous stimuli. The deviations brought about by altered contact, by deep inspiration and expiration, and by coughing,

[1] All tracings except figs. 9, 14, 15, 18, have been reduced to one-eighth their size.

are all readily recognised after some experience, and are readily differentiated from those depending wholly upon psychic influences. Warm hands naturally permit a larger current than cold hands. The level of the curve rises when the skin in contact grows warmer or moister, and descends with increase of coldness in the skin (see fig. 1).

§ 2.—*Fluctuations of the Galvanometer from Psychic Causes in Normal Individuals.*

Expectation.—As soon as the galvanometric experiment begins, and the circuit through the test person is closed, there is a rather rapid rise with some fluctuation of a curve induced by expectant attention. Tarchanoff was much struck by this. Attention is, as Bleuler [1] has pointed out, nothing more than a special form of affectivity. Attention, interest, expectation, are all emotional expressions. The extent of this expectation curve rises in normal individuals, depending upon their varying degree of affectivity. Expectation is not only manifested at the beginning of an experiment in the galvanometer curve, but may be also observed throughout the experiment in connection with every stimulus, sensory or verbal. It is particularly strong in connection with the threat of pricking with the needle, or threat of letting fall a heavy weight. The influence of expectation on the curve becomes less with each repetition of the same series of stimuli, and seems to disappear wholly with indifferent stimuli; while, with the threat stimuli just referred to, which are more lively and actual, repetition may diminish the curve, or at times increase it if the test case is uncertain whether the threats in the repetition are to be a real prick of the needle or an actual fall of the weight. In beginning an experiment, we therefore wait until the first influence of the emotion of expectation has subsided.

Emotion.—Excluding the affect of attention, we find that every stimulus accompanied by an emotion causes a rise in the electric curve, and directly in proportion to the liveliness and actuality of the emotion aroused. The galvanometer is therefore a measurer of the amount of emotional tone, and

becomes a new instrument of precision in psychological research.

Imagined emotion.—The amount of deflection seems to stand in direct relation to the *actuality* of the emotion; but, as Tarchanoff pointed out, the presentation of an emotion already outlived to the imagination does deviate the galvanometer, such deviation depending naturally upon the facility of the test person in living over the old emotion in his imagination. The following experiment, tried upon one of the writers, is an illustration: The list of stimuli was placed before him, while the reader of the deviations called off at intervals Nos. 1—2—3—4—5—6, allowing time for concentration upon the idea, and for the rise and subsidence of the wave. Between the periods of concentration on the emotional images, the test person allowed his eyes to wander indifferently about the room, and his mind to run on in different objects seen.

An Experiment in the Deflection of the Galvanometer in Imagined Conditions.

	Amount of deviation of galvanometer.
(1) Expectant attention.	
(2) Imagined threat of prick with needle ...	4·3 cm.
(3) Imagined threat of fall of heavy weight ...	1·6 cm.
(4) Imagined grief...	2·8 cm.
(5) Thought of an amusing story	1·8 cm.
(6) Thought of a painful illness in 1888 ...	1·6 cm.

Series of stimuli used.—A series of stimuli, sensory and verbal, strong and indifferent, intellectual and emotional, was arranged and tested upon numerous normal individuals, besides which word associations were used in connection with the galvanometer. In some of the experiments the test person was in an adjoining room, the electric connections and signals being easily adjusted for this purpose. The following is the series of stimuli:—

(1) A loud whistle.
(2) Actual fall of a weight with a very loud noise.
(3) Multiply 4 by 5.
(4) Multiply 9 by 11.

(5) Multiply 8 by 12.
(6) Sudden call of person tested by name.
(7) Where do you live?
(8) What is the capital of Switzerland?
(9) What is the capital of France?
(10) How old are you?
(11) Are you married?
(12) Were you engaged once before?
(13) Have you been long at your present employment?
(14) Threat of prick with needle after counting 1—2—3.
(15) Threat of allowing heavy weight to fall after counting 1—2—3.
(16) What is your first name?
(17) What is the first name of your wife?
(18) Is she pretty?
(19) We have now finished.

The verbal stimuli were varied to a slight degree with various individuals, to adapt them to different conditions and circumstances, but the general character of the stimuli was the same.

These stimuli were ordinarily repeated three times in each individual, normal or pathological, and subsequently the series of word stimuli were given for the word associations, and these were also repeated once or twice. From seventy curves, fig. 2 (H., nurse, Series III.) is selected as a general illustration of the galvanometric curve. This man was emotional and in the third series here presented the curves are smaller and more rounded than in the first and second series. At the same time they serve to show the character of the emotional curve. Stimuli 3, 4, and 5, although they were but simple multiplication, induced an emotional curve, because H. was a nurse and was embarrassed in doing mental arithmetic before experimenters. Stimuli 8, 9, and 10 were practically exhausted in this third trial and show very little. Between 10 and 11 someone entered the room. The weight was let fall twice between 13 and 14 instead of at 2, and being unexpected produced a large and a smaller wave of alarm. The threatened prick of the needle at 14 and threat of fall of large leaden weight at 15 still produced large waves, and show how strongly actuality

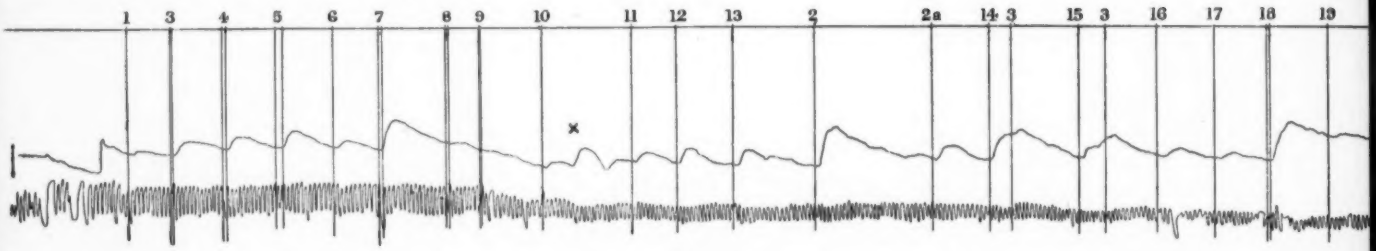

FIG. 2.

Galvanometer and pneumographic curves in a normal person (H., a nurse). The numbers at the top of each stimulus line correspond to the series of nineteen mixed stimuli printed in the text. 2 and 2a representing two falls of the weight occurred between 13 and 14 instead of between 1 and 2 in this curve, which was the second repetition of the series. Between 10 and 11 someone entered the laboratory.

in an apprehension influences the curves. Again, at 18 the enquiry if his wife was pretty, she being far from so, induced a lively emotion and correspondingly high wave, for this question was here a surprise as well, not having been asked in the preceding series.

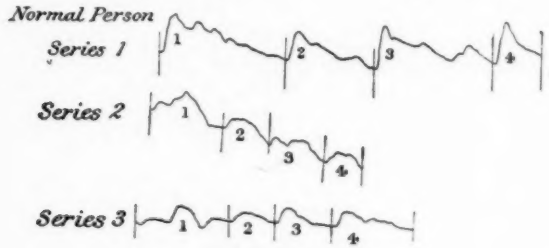

FIG. 3.

Repetition of same stimulus questions in a normal person (H., a nurse) three successive times to show gradual exhaustion of emotional wave in the galvanometer curve. In 3rd series question 1, someone entered the laboratory and caused an extra wave.

Exhaustion of stimulus by repetition.—When the first series of stimuli is recorded, the curves are usually characterised by abrupt ascent and descent with rather sharp summits. The curves diminish in size and the summits

FIG. 4.

Here G., a nurse, is asked about a quarrel with another nurse, H. The fluctuating galvanometer waves 21 and 22 represent the wavering emotions aroused.

become more rounded by each repetition, showing a slower excitation and slower reaction of the emotion. This is well illustrated in fig. 3, where several curves induced by the same stimuli in the first, second, and third series in the same individual are reproduced. Wave No. 1 in Series I.

also exhibits in the descent the fluctuating character of an emotion which is slowly and waveringly passed off. This is even better shown in fig. 4, from Case G., who was asked questions calculated to produce a complex emotional state such as the galvanometer perfectly indicates. In quite a number of instances the heights of the waves of the three successive series were measured and the following two illustrations are selected as examples of the differences in height (in millimetres) of the curves of the stimuli in the three series. Waves were selected which had not been affected in any of the series by interruptions, change of contact, coughing or deep inspirations.

Table 1, *Case of H. Diminishing Excursions of Galvanometer in Successive Stimulations.*

Stimuli. / Case of H.	4 × 5.	9 × 11.	Call by name.	Where do you live?	Capital of Switzerland?	How old are you?	Are you married?	Were you engaged before?	Have you been a nurse long?	Threat with needle.	Threat with weight.	Average.
Series I. ...	34	18	5	38	14	24	18	27	26	36	22	24
Series II. ...	11	12	4	18	9	9	6	4	6	25	59+	10·4
Series III. ...	8	8	4	18	1	3	6	9	9	18	13	8·4

Table 2, *Case of G. Diminishing Excursions of Galvanometer in Successive Stimulations.*

Stimuli. / Case of G.	4 × 5.	8 × 12.	Where do you live?	Capital of Switzerland?	Capital of France?	How old are you?	Were you once engaged?	Have you been a nurse long?	Do you like the work?	Threat with needle.	Threat with weight.	Average.
Series I. ...	9	10	7	7	8	5	10	5	8	17	15	8·6
Series II. ...	6	6	4	7	4	6	4	5	6	14	17	6·2
Series III. ...	3	5	3	5	3	4	6	4	5	16	15	5·4

NOTE.—In the averages of these two tables the eleventh column of figures was not included as the emotion of expectation that the weight would really be dropped modifies especially the second trial, while in the third trial there was less of such expectation.

In these tables the falling off of the height of the emotional curve is very well shown, and in both the livelier affects produced even in repetition by actual threats of the needle and weight are typical. In Series II. of the first table the threat with the weight raised the curve to over fifty-nine because the trial person thought that the weight would actually fall in this experiment, whereas before it was a threat only.

Latent time.—It was noted by Tarchanoff that the galvanic wave began to rise from one to three seconds after a stimulus was given. We have verified this period of latent time in all normal conditions, but the latent time varies with different people and at different times. In the curves that we have thus far taken we could not well complicate the apparatus with a chronograph adjustment, and have estimated the space of latent time in a number of normal cases by measuring the distance of the curve from the moment of stimulation to the beginning of ascent of the emotional curve, taking the measurements in millimetres. The kymograph drum revolved slowly. The following results were obtained. Nurse B. with the series of mixed stimuli given above showed in the first series an average of 2·06 millimetres; the repetition of the second series averaged 2·55 millimetres; with Nurse G. and the same series of mixed stimuli in Series I. the average was 1·85, in the second 1·76, and in the third or final series 2·32 millimetres. Dr. P. with the same series showed an average latent period in the first trial of 3·15, and in the repetition an average of 4·40. Dr. R. with the same series had an average period in the first trial of 4·05 millimetres, and in the second trial of 4·50 millimetres. In a series of word associations Dr. R. showed at first an average period of 2·95 millimetres, and in the repetition immediately after the average was 4 millimetres. With word associations Nurse H. showed in the first series an average latent period of 2·26; in the repetition or second series the latent period was increased to 3·55, and with a third trial of the same words the latent period had become 4·14. These figures with regard to the latent period show therefore that with repetition there is an increase of the

latent period of time simultaneously with the rounding off and diminishing amplitude of the curve, both corresponding with exhaustion of the power of the stimulus. We were unable to determine in this investigation that there was any marked difference in latent time in relation to the various forms of stimulation whether physical or psychic, and when psychic with or without answer to questions or words, though such differences will probably be discovered by further experiment directed to this end.[1]

Normal individual variations of galvanometer curve.— We find considerable difference in the curves made by the galvanometer in normal persons. In some the waves are

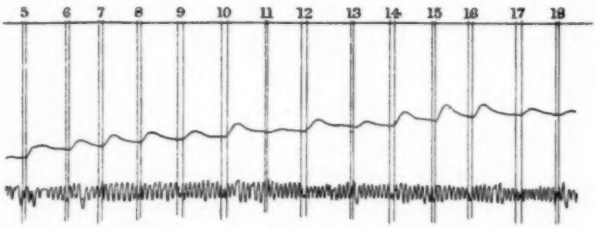

FIG. 5.

Dr. R., normal curve with rather indifferent word-association stimuli. Unemotional type.

of rather small and even excursion, corresponding to the unemotional or phlegmatic nature of the test person. In others there is wide excursion, with fluctuating or bifurcated waves, rapid ascents and descents, expressing great emotional lability. These normal variations are illustrated in figs. 5 and 6.

[1] With a stop-watch we estimated that the time of revolution of the drum was 4·5 millimetres in five seconds. Hence the latent time in the above normal individuals was about as follows :—

Latent time in Seconds.	B.	G.	Dr. P.	Dr. R.	Dr. R. Word Assoc.	H. Word Assoc.
First series ...	2·28	2·05	3·5	4·5	3·27	2·51
Second series ...	2·83	1·95	4·88	5	4·44	3·94
Third series ...		2·57				4·6

Chapter III.—The Pneumograph as an Indicator of Psychic Processes.

The relation of the respiratory innervation curve to psychic processes in both normal and pathological conditions has not yet been thoroughly investigated. Mosso (1879-1893) was one of the earlier investigators in the physiological application of the pneumograph and could reach no satisfactory conclusions from a study of the respiratory curve under sensory stimulation. Delabarre [2] states that respiration increases in frequency and depth with attention to sensory stimulation, and with

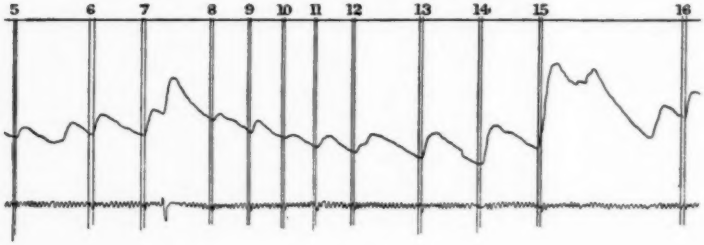

Fig. 6.

H., an attendant, normal curves, very labile emotions. The numbers here correspond to the series of mixed stimuli, 15 is threat of weight.

mental processes increases in frequency and diminishes in depth. Lehmann [7] states that every pleasant impression increases the depth of breathing, and that strong unpleasant impressions are accompanied by several deep respiratory movements. Mentz [9] employed pleasant and unpleasant acoustic stimuli in a study of the pulse and breathing, and as regards respiration observed with strong stimulation first slowing and then shortening of the respiratory movements. He noted also a marked influence of attention on the results. Involuntary attention generally induced prolongation of breathing, while voluntary attention often caused abbreviation of the movements. Pursuing his studies farther he investigated the action of pleasant and

unpleasant stimuli and of the effects upon pulse and respiration. As regards the former, pleasant feelings lengthened the pulse curve and unpleasant ones shortened it, and he regards the respiratory curve as running a parallel course. With affects there was prolongation of the respiratory movements, and with increasing strength of the affects an increasing height or depth of the breathing curve. Zoneff and Meumann [17] finding nothing sufficiently definite in literature in relation to the correspondence between respiration and circulation and psychic or emotional processes, have made an exhaustive research upon normal individuals, employing various stimuli, optic, acoustic, gustatory, cutaneous and psychic (arithmetical problems and space conceptions) and studied at the same time the effects of voluntary attention and pleasant and unpleasant impressions upon the breathing and pulse. They found that as a rule attention produced acceleration of the breathing, especially at the end of the stimulation, and in addition to acceleration the breathing might become more shallow or be inhibited. This inhibition may appear as shallow and more rapid breathing, or there may be a partial or complete standstill of the respiration, and is greater in direct proportion to the degree of attention. Complete inhibition was found more often in attention to sensory than to intellectual stimulation. There were variations in the results in different individualities. There were fluctuations in the curves which they considered as being due to fluctuations in attention. In relation to pleasant and unpleasant stimuli they concluded that all pleasant sensations cause shallowing and acceleration of the breathing, and all unpleasant sensations deepening and slowing of respiration, or, in other words, that the former diminish and the latter increase respiratory function. In experiments with diversion of the attention together with stimulation, they found that emotional effects upon breathing and pulse ceased. In experiments with concentration of attention on stimulus and sensation, attention strengthened the effects of both pleasant and unpleasant feelings upon the curves. While their work is the best that has yet appeared upon this

subject, it must still be confessed that experiments of this nature carried out upon the trained assistants or students connected with the laboratory are more or less artificial, and this, together with the extremely simple character of the stimulation, would make their criteria for the more complex emotional phenomena with which we have to deal only relatively valuable.

Martius and Minnemann [8] in a thoroughly iconoclastic and yet excellent work point out many fallacies in the studies of Lehmann, Menz and Zoneff and Meumann, artefacts of a mechanical nature, and wrong conclusions as to the relations between affects, and pulse and breathing curves. They themselves find the normal respiratory curve inconstant, subject to variations due to age, temperament, perseveration of affect, reactions from the affect, embarrassment from the experiment, undue interest in the procedures, &c., and their chief conclusion is that the main changes in breathing in emotional conditions consist of quickened or lengthened tempo, with diminished height in either case.

Believing that a study of the inspiratory curve would throw the most light upon the relation of respiratory innervation to psychic processes, we set before ourselves several problems for consideration, viz., the character of the usual respiratory curve, the character of the curve in stimulation without verbal reaction, the influence of verbal reaction with indifferent stimuli upon the curve, whether distinct emotional complexes affected uniformly the pneumographic curve, whether there were marked disturbances of the respiratory without corresponding changes in the galvanometric curve, and, finally, what influence attention has on both galvanometer and pneumograph. We have not been able as yet to reach satisfactory conclusions on all of these points, for the material already available is more than we have yet had opportunity thoroughly to investigate; but so far as they go the results obtained are of interest. The figures in the table given below show a regular, though not constant, relation between the galvanometric and the pneumographic curves in one case.

Measurements to Show the Relation in Frequency and Amplitude of Inspirations to Ascending and Descending Portions of the Galvanometer Wave.

Nurse B. Series I.	Whistle.	Weight falls.	4 × 5.	9 × 11.	8 × 12.	Where do you live?	What is the capital of Switzerland?	Are you married?	Threat of needle.	Threat of fall of weight.	Average
Average distance apart of inspirations in the ascending galvanometer curve	2·6	2·83	2·75	2·5	2·2	2·62	2·5	1·87	2·6	2·2	2·46
Average distance apart of inspirations in the descending galvanometer curve	2·18	2·36	2·5	2·14	2·42	2·2	2·3	2·42	2·5	2·3	2·33
Average height of inspirations with ascending galvanometer curve	15·8	15	14·5	14	12·8	11·25	12·5	13·6	16·4	14·6	14
Average height of inspirations with descending galvanometer curve	14·33	13·41	13·75	13	11	9·8	11·7	13	16·4	14·23	13

To obtain these relations it is necessary to select an experiment in which the galvanometric curve has not been influenced greatly by the several sources of error, and the simultaneous pneumographic curve has not been modified too much by verbal reaction, coughing, &c. Taking the typical curves of several such series, measurements were made to determine the relative number of inspirations synchronous with the ascending galvanometer curve, and also with the descending galvanometer curve. The amplitude of each inspiration was also measured and averaged for the same purpose, and the measurements are recorded in millimetres. It will be seen that the ascending portion of the galvanometer curve, which is the result of an emotional stimulus, is accompanied by fewer inspirations as well as by deeper ones. While this seemed to be a general rule in this instance, we find variations in different individuals with the same mixed series of stimuli, and in some cases the reverse.

The stimuli in the table were unpleasant rather than pleasant to the test person. But the determination of the quality of the emotional tone in any such experiment is very difficult. The forced and artificial situation of the test person in itself induces unpleasant feelings, and any pleasant stimulus must therefore simply bring about a certain relief or relaxation in a situation of unpleasant tension. The nervous tension during an experiment must naturally influence the breathing, and a pleasant stimulus is apt to produce only a temporary lessening of such tension. This is a criticism we would make of the Zoneff and Meumann experiments, and of experiments with the pneumograph in general. It is altogether probable that there are more inexplicable influences at work in relation to the pneumographic curve than we are at present able to comprehend. There are many respiratory fluctuations which have nothing to do with the emotions, but are the result of physical or intellectual processes, with the enforced quiet of body of the test person, with the disposition to speak, with tendencies to cough or to swallow, &c. Furthermore, there will be a difference in the curve if the stimulus occurs during an inspiration or an expiration, and there are individual variations dependent upon temperament, upon lability of the emotions.

We have, therefore, not been greatly impressed with the value of a possible relation between the galvanometric and pneumographic curves since it is not constant, and the more we have studied comparatively the two synchronous curves, the more have we been impressed with a surprising divergence between the influences at work upon them. We have studied hundreds of waves in every conceivable manner. For instance, we have taken series of galvanometric curves and carefully measured the length of each inspiration, and the intervals between inspirations, as related to the point of stimulus, to the latent space before the ascent of the galvanometer wave, to the ascending curve, to the crest, to the descending curve, and to the space to the next point of stimulus, without developing any regular and constant relationship or correspondence, though we think this may ultimately be shown to exist in some degree. On the contrary,

we have found thus far that the influences at work upon the two curves reveal an astonishing regularity of difference. When the emotions are very labile, and show the most marked excursions in the galvanometer curve, the respiratory curve is often regular and even (fig. 7). On the other hand,

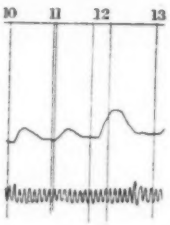

FIG. 7.

Dr. P., normal good-sized galvanometer curves with fairly regular respiratory curve.

in instances both normal and pathological, where the galvanometer curve is marked by little fluctuation, or even by none, as in some cases of katatonia, there will often be most decided variations in the pneumographic curve. We often

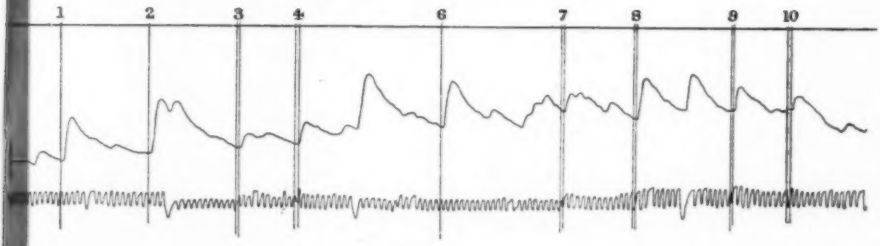

FIG. 8.

Dr. S., a patient with paranoid dementia (Case No. 3). Extraordinary labile emotions expressed in galvanometer curve. Considerable tension in pneumographic curve from stimulus 2 (fall of weight) on, with relaxation and deeper breathing beyond stimulus 7. An example of perseveration of tension for a long period in the pneumographic curve.

note a change in character in the pneumographic curve, not so much with each separate stimulus, but during the whole course of a series of stimuli as if expectant attention and nervous tension diminished the inspirations during the early

part of the series, and as if there were a relaxation during the later half with longer inspirations (fig. 8). There does not seem to be the intimate and deep relationship between the respiratory function and the unconscious emotions that

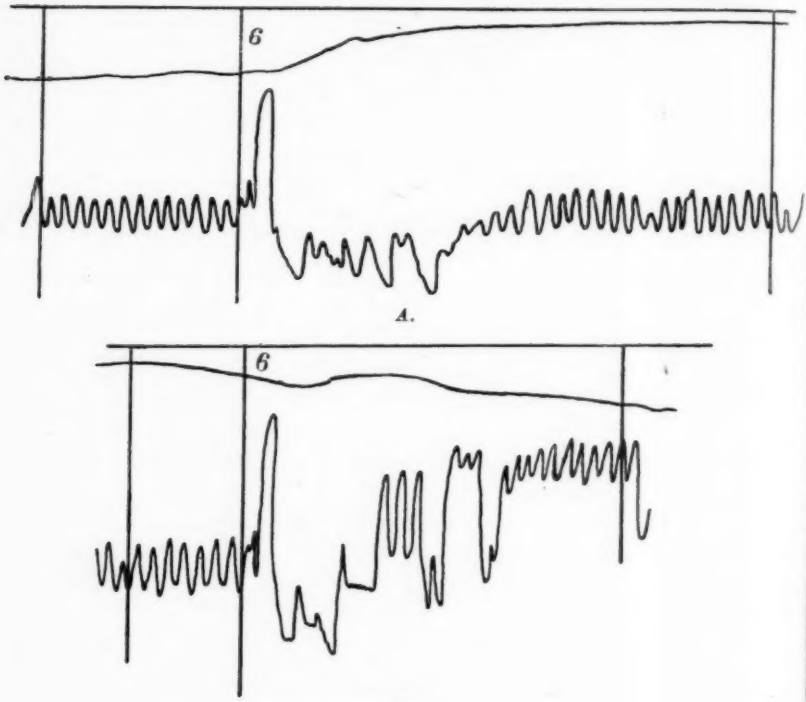

FIG. 9.

J., acute katatonic stupor (Case No. 10). *A* is a wave selected from the series in which 6 is sudden call by name. The galvanometer curve is slight, but the change in the pneumographic curve is notable. *B* is the same stimulus in the repetition of the series.[1]

exists between the sweat glandular system and these emotions. It is a matter of every-day experience that the respiration is influenced by our conscious emotions, especially when they are strong, as instanced in such expressions as

[1] Fig. 9 is reproduced the actual size of the tracing.

"bated breath," "breathless with astonishment," &c. Such inhibitions of breathing are noticeable in many pneumographic curves, particularly in association with expectation and tension. But do, perhaps, the emotions of the subconscious, roused up by questions or words that strike into the buried complexes of the soul, reveal themselves in the galvanometer curve, while the pneumographic curve is comparatively unaffected? Respiration is an instrument of consciousness. You can control it voluntarily while you cannot control the galvanometer curve. The respiratory innervation is closely associated with speech innervation, anatomically and functionally, and the physical connection in the brain is, perhaps, one of the closest and earliest. Let us take these remarkable curves of a case of acute katatonia (figs. 9A and 9B), which may be regarded as a psychological experiment in diverting both attention and ordinary emotion. Attention and all other emotions being practically diverted by the pathological process, the galvanometer curve is slight (indeed, in the *second* repetition it was a straight line), but the sudden call of the patient by name produced the extraordinary fluctuations in the respiratory curve, though nothing was apparent in his outward demeanour to show that he was conscious in any degree of the stimulus. He may have been conscious of the call, but we had no means of determining this. In the repetition the same fluctuations occurred, proving that they were not fortuitous. The only reasonable explanation of this phenomenon, in our opinion, is that the call of the name developed a disposition to speak, stimulated the hearing centre, and the closely-associated speech centre, the motor innervation from which acted upon the respiratory muscles. Ordinarily a sudden call by name, which is one of the strongest and deepest of stimuli, produces an answer. In this instance the call by name was a stimulus that acted as in a simple reflex process, and led to motor manifestations in the respiratory muscles connected with the motor speech centre, analagous to the contraction of the eyelids in response to a sudden flash of light. Fig. 10 is another instance of almost like character.

While inconstancy of emotional variations in the re-

spiratory curve and in correspondence with the galvanometer curve has been the rule in our findings thus far, we have learned that inhibitions, when they occur as an expression of expectant attention or of other emotions, are almost always shown in the expiratory curve and not in the inspiratory, which would accord with our idea that active, intellectual, emotional or conscious innervation is chiefly associated with inspiration, whereas expiration is rather a physical process or relaxation, prone to be inhibited, but not otherwise affected by the active respiratory nerves.

In reiterating our opinion that the galvanometer curve is probably more intimately connected than the pneumographic

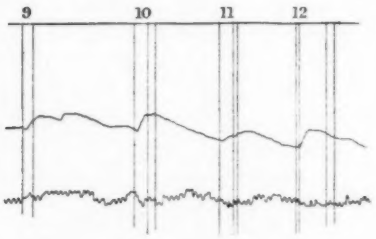

FIG. 10.

Miss S., paranoid dementia (Case No. 2), stimuli 9, 10, 11, 12, correspond to numbers in the mixed series printed in the text. The noteworthy changes in the respiratory curve are due to her constant "disposition to speak." She did not speak except in answer to the questions given, but she apparently whispered most of the time between audible answers. Sometimes there was slight movement of the lips, when real whispering was not apparent.

curve with the subconscious emotional complexes, we would add that there is a greater tendency also to persistence in the pneumographic curve when emotion is expressed in it, for the galvanometer curve subsides rather quickly with the fall of the emotion, while the pneumographic curve may show traces of conscious reminiscence of the emotional stimulus for a much longer time. The galvanometer is rather an index or measurer of acute feeling tone.

Thus far, for the purposes of this study of the curves under normal conditions, we had made some forty series of curves in eight normal individuals, educated and uneducated.

After this we made some thirty series of curves in eleven cases of dementia præcox of different types, viz.: Dementia paranoides three, hebephrenia two, and katatonia six cases (three chronic and three acute), and to these tests we will now turn our attention.

Chapter IV.—The Galvanometric and Pneumographic Curves in Dementia Præcox.

Before recording the results of our experiments in dementia præcox it is necessary to say something of the psychology of the disorder. The chief characteristic in the mental condition of these patients is a peculiar disturbance of the emotions. In chronic conditions we have, as Kraepelin has clearly shown, an "emotional atrophy." In acute conditions there is a species of "incoördination" or "ataxia" between affectivity and concepts, as well demonstrated by Stransky [14]. The emotional disturbance has also been called "inadequate emotional tone." But these phrases represent rather the superficial impression that these patients make upon the physician. As soon as one examines the phenomena analytically and critically, the difficulty of attaining to a common point of view as regards all the morbid emotional symptoms is found to be extraordinary. We see at once that in most cases of dementia præcox all of the emotions are not changed or destroyed. We find, indeed, on closer analysis that many normal feelings are present. Cases with complete loss of all emotion are exceptional. Elementary affects, such as fright, anxiousness, pleasure, anger, embarrassment, shame, &c., are usually preserved. There is even at times an increased affectivity, or real nervous sensitiveness, present. Furthermore, in cases where one would expect more or less diminution of affectivity from their previous conduct and life the elementary feelings are still maintained. The disorder is then shown in what Janet calls the *fonction du rèel*[1] or the psychological adaptation to the environment. It is hardly to be expected that we should find characteristic disturbances in such patients by our

[1] "Acting up to realties."

experimental method (psycho-galvanic), since they would lie in quantitative differences between the various feeling tones. Even were qualitative changes there they would be too small for recognition.

One of the chief factors in psychological adaptation to environment is attention, which renders possible all the associations necessary to normal existence. In dementia præcox, especially the katatonic form, there are marked disorders of attention, which are shown by lack of power of voluntary concentration; or, otherwise expressed, objects do not excite in the diseased brain the affective reaction which alone permits of an adequate selection of intellectual associations. This defective reaction to stimuli in the environment is the chief feature of dementia præcox. But this disorder is not simple and elementary; on the contrary, it is very complicated. What is its origin? There is in the psychology of dementia præcox still another characteristic which throws light upon the problem. By means of word associations and subsequent analysis we find in these cases among other abnormal manifestations certain thought complexes associated with strong emotional tone, one or several of which are fundamental complexes for the individual and embody as a rule the emotions or experiences which immediately preceded the development of the mental disorder. In suitable cases it is possible without much trouble to discover that the symptoms (delusions, hallucinations, insane ideas) stand in close relation to these psychological antecedents. They, in fact, as Freud has shown, determine the symptoms. Freud applied his method particularly to hysteria, in which he found conscious or unconscious constellations with strong affective tone which may dominate the individual for years, or even the whole life through, by their might exerted upon associations. Such a morbid complex plays the part of an independent being, or soul within a soul, comparable to the ambitious vassal who by intrigue finally grew mightier than the king. This complex acts in a particular way upon the psyche. Janet [5] has described it in an excellent manner in his book. The complex robs the ego of light and nourishment, just as a cancer robs

the body of its vitality. The sequelæ of the complex are briefly as follows: Diminution of the entire psychic energy, weakening of the will, loss of objective interest and of power of concentration and of self-control, and the rise of morbid hysterical symptoms. These results can manifest themselves also in associations, so that in the hysterical we find clear manifestations of emotional constellations among their associations. But this is not the only analogy between dementia præcox and hysteria. There are numerous others which we cannot here describe in detail. One may, however, call attention to the large number of undoubted katatonic processes which were formerly called "degenerative hysterical psychoses." There are many cases, too, of dementia præcox which for years are not to be distinguished from hysteria. We call attention to the similarity of the two disorders here in order to show that our hypothesis of the relation between "psychological adaptation to environment," and an emotional complex is an established fact in the matter of hysteria. If we find in dementia præcox similar conditions, we are justified in assuming that here, too, the general disturbances of mind may have a close causal relationship with an underlying complex. The complex is naturally not the only cause of dementia præcox, as little as it is of hysteria. Disposition is also a chief agency, and it is possible that in the disposition to dementia præcox affectivity brings about certain irreparable organic disturbances, as for instance metabolic toxins.

The difference between dementia præcox and hysteria lies in certain irreparable sequelæ and the more marked psychic disturbances from the former disorder. Profound general disturbances (delirium, severe emotional crises, &c.), exceptional in hysteria, are usual in dementia præcox. Hysteria is a caricature of the normal, and therefore shows distinct reactions to the stimuli of the environment. In dementia præcox, on the other hand, there is always defective reaction to external stimuli. There are characteristic differences in relation to the complex. In hysteria with very little trouble the complex may be revealed by analysis, and with a good prospect of therapeutic advantage in the procedure.

But in dementia præcox there is an incapability of being thus influenced. Even if, as is sometimes possible, the complex may be forced to reproduction, there is as a rule no therapeutic result. In dementia præcox the complex is more independent and more strongly detached, and the patient more profoundly injured by the complex than is the case in hysteria. For this reason the skilled physician is able to affect by suggestion acute hysterical states, which are nothing but irradiations from an excited complex, while he fails in dementia præcox where the inner psychic excitement is so much stronger than the stimuli of the environment. This is also the reason why patients in the early stages of dementia possess neither power of critical correction nor insight, which never fail in hysteria even in the severest forms (Raimann [11]).

Convalescence in hysteria is characterised by gradual weakening of the complex till it vanishes entirely. The same is true in the remissions of dementia præcox, though here there is always some vestige of irreparable injury, which, even if unimportant, may still be revealed by study of the associations.

It is often astonishing how even the severest symptoms of dementia præcox may suddenly vanish. This is readily understood from our assumption that the acute conditions of both hysteria and dementia præcox are the results of irradiations from the complex, which for the time conceal the normal functions that are still present. For example, some strong emotion may throw a hysterical person into a condition of apathy or delirium, which may disappear the next moment through the action of some psychological stimulus. In like manner stuporous conditions may come and go quite suddenly in dementia præcox. While such patients are under the spell of the excited complex, they are for the time completely cut off from the outside world, and neither perceive external stimuli nor react to them. When the excitement of the complex has subsided, the power of reaction to the environment gradually returns, first for elementary and later for more complicated psychological stimulation.

Since, according to our hypothesis, dementia præcox can be localised in some dominating psychological complex, it is to be expected that all elementary emotional reactions will be fully preserved, so long as the patient is not in complete control of the complex. We may, therefore, expect to find in all patients with dementia præcox, who show psychological adaptation in elementary matters (eating, drinking, sleeping, dressing, speaking, mechanical occupation, &c.) the presence of some adequate emotional tone. But in all cases, where such psychological adaptation fails, external stimuli will produce no reaction in the disordered brain, and even elementary emotional phenomena will fail of manifestation, because the entire psychic activity is bound up with the morbid complex. That this is an actual fact is shown in the results of our experiments.

The following is a brief *résumé* in each case of the features that have interest for us here :—

(1) H., male, aged 43, teacher of languages. Insane first ten years ago. Well educated and intelligent. Entered an asylum for a time in 1896. Passed through a light period of katatonia with refusal of food, bizarre demeanour and auditory hallucinations. Later always persecutory ideas. In August, 1906, he murdered one of his supposed persecutors, and since then has been in this asylum. Very precise and correct in his dress and conduct, industrious, independent, but extremely suspicious. Hallucinations not discoverable. Diagnosis—*Dementia paranoides.*

(2) Miss S., aged 61, dressmaker. Became insane about 1885. Innumerable bizarre delusions, delusions of grandeur, hallucinations of all the senses, neologisms, motor and language stereotypy. Conduct orderly, neat, industrious, but rather querulous. Is on parole and shows considerable independent activity. Diagnosis—*Dementia paranoides.*

(3) Dr. S., male, aged 35, chemist. Became insane about 1897. Very intelligent and reads numerous scientific books. Has many wants and makes many complaints. Extremely careful in dress, and is extraordinarily neat. Numerous grandiose ideas and hallucinations. No katatonic symptoms. Diagnosis—*Dementia paranoides.*

(4) Mrs. H. O., aged 44, farmer's wife. Became insane in 1904 with an attack of hebephrenic depression. Since the end of

1906 in a second attack of similar character. Speaks only in whispers. Somewhat inhibited, anxious, and hears very unpleasant voices. Works industriously and spontaneously. Neat in dress and in care of her room. Diagnosis—*Hebephrenic depression.*

(5) Mrs. E. S., aged 43, merchant's wife. Became insane in 1901. Occasionally light maniacal excitement, never confusion at first, but rapid dementia. Now greatly demented, inactive, and vexes other patients. Unemotional, indifferent and untidy in dress. Without interest in her husband or surroundings. Chatters a great deal, but quite superficially, and it is impossible in any way to rouse in her any of the deeper emotions. Diagnosis—*Hebephrenia.*

(6) A. V. D., male, aged 39. Entered the asylum in 1897. From the beginning quiet, unemotional, somewhat timid and anxious. Speech fragmentary and indistinct, and talks most of the time to himself. Makes meaningless gestures with the hands. Has to be cared for by the attendant in all matters. Cannot work. Shows neither homesickness nor desire for freedom. Automatism on command and at times catalepsy. Diagnosis—*Chronic katatonic stupor.*

(7) Sp., male, aged 62, factory worker. Became insane in 1865. In the early stages several attacks of katatonic excitement. Later chronic stupor with occasional raptus. In one attack of raptus tore out one of his testicles with his hand. At another time suddenly kissed the attendant. During a severe physical illness at one time he suddenly became quite clear and approachable. Speaks only spontaneously and at long intervals. Works only mechanically when he is led to it. Stereotyped gestures. Diagnosis—*Chronic katatonic stupor.*

(8) F., male, aged 50. Became insane in 1881. At first for a long period depressed inhibition. Later mutism, with occasional outbursts of abusive language on account of voices and numerous hallucinations. At present constant hallucination, though he is quiet, speaking only when addressed, and then in a low, short fragmentary manner. Occasionally outbreaks of abuse because of the voices. Works mechanically, and is stupid and docile. Diagnosis—*Chronic katatonia.*

(9) J. S., male, aged 21. Became insane in 1902. Stupid, stubborn, negativistic, speaks spontaneously not at all or very seldom, wholly without affectivity and apathetic, sits the whole day in one place, wholly disorderly in dress. Once in a while demands release with some irritation. Diagnosis—*Mild katatonic stupor.*

(10) J., male, aged 21, student of philosophy and very intelligent. Became insane about 1901, when he had a short attack. The second attack came in December last (1906). At times excited, wholly confused, and strikes about him. Incessant hallucinations. Wholly wrapt up in his inner mental processes. In occasional intervals of some lucidity, the patient states quite spontaneously that he has no feeling at all, that he cannot be either glad or unhappy, that everything to him seems wholly indifferent. Diagnosis—*Acute katatonic stupor with raptus.*

(11) M., male, aged 26, merchant. Became insane in 1902. At first maniacal excitement. Later dull apathy and occasional exhibition. Then gradually increasing stupor, with complete detachment. Now mutacismus, and tears out his beard, but at other times rigid and cataleptic. Diagnosis—*Acute katatonic stupor.*

The galvanometer curves were in many of the tests with dementia præcox extraordinary. As in normal individuals we found, where there was reaction at all, a gradual exhaustion of the power of the stimulus in repetitions of the same series, so that the waves became smaller in the second, and still smaller and more rounded in the third series. In some cases, where the waves were small in the first series, they disappeared altogether in the third. In fig. 8 we have a good example of a very labile galvanometer curve from a case of dementia paranoides, in which we have abrupt and high ascents, at times with large bifurcations. This was the second series of this patient, and the curves are smaller than in the first. They may be compared with the labile normal curve of fig. 6, which was the first series ; and also with fig. 10, another case of paranoid dementia, but in which the galvanometer wave is rather unemotional, while the pneumographic curve shows in this instance such marked changes owing to the disposition to whisper. The type of galvanometer curve, shown in fig. 8, is also characteristic of curves we have taken in hysteria.

In the hebephrenic type there is nothing especially noteworthy in the curve, either in point of great lability or smallness of wave. In the katatonic forms of dementia præcox, especially in the acute forms, we observed, however, extraordinary variations from the normal in the character of the

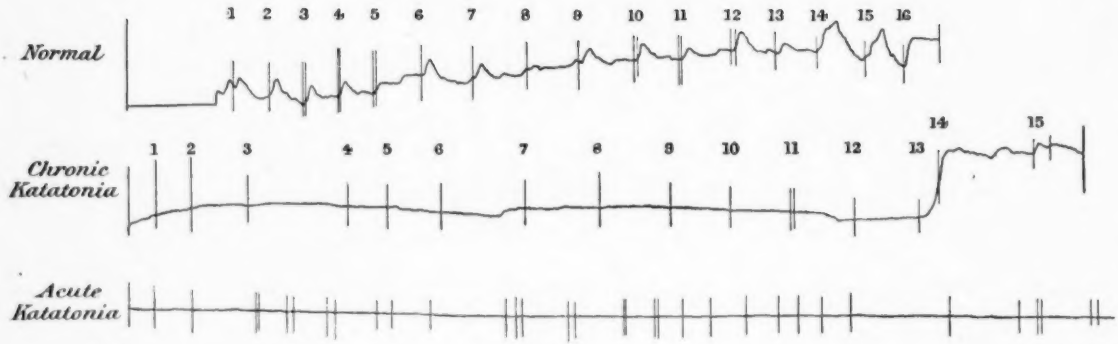

FIG. 11.

Three galvanometer curves for contrast. The first curve is a normal one, with series of mixed stimuli (Miss B., a Canadian). The second curve is that of Sp. (Case No. 7), one of chronic katatonic stupor. Note presence of elementary emotion at stimulus 15. The third curve is that of J. (Case No. 10, acute katatonic stupor). No change whatever in the galvanometer curve to any of the mixed stimuli.

curve. Not only is the latent time longer, but the waves are almost always of gradual ascent, and very small if present at all. Figs. 9A and 9B, from a case of acute katatonic stupor, present illustrations of curves brought about by sudden call of the name. The galvanometer curve is exceedingly slight, but the pneumographic curve shows the singular changes previously mentioned. In fig. 11 we have three galvanometer curves shown. The upper one is from a normal person, with the series printed in the text. The middle one is that of a case of chronic katatonic stupor (Sp.), which is characterised by almost no reaction to any stimuli until 14 is reached, when the threat of sticking with a needle (and the actual stick where the line crosses the up wave) produced a great rise in the curve. A slighter rise occurred at 15, the threat of fall of weight. This is an example of reaction to an elementary emotion in a chronic case where some emotional tone is still present. The lowest line in fig. 11 represents the galvanometer curve of an acute case of katatonic stupor (J.), and here it is seen that the line is perfectly straight, that not one of the mixed series of stimuli printed in the text had the slightest effect; whistle, drop of weight with loud noise, sudden loud call by name, actual hard pricks with the needle—nothing brought out a response in the galvanometer. The pneumograph could not be applied in this case. Our experience with the six cases of katatonia is that such curves are characteristic for the type, and bear out our idea of the psychology of the disease as recorded above.

Another feature of importance in these cases is the matter of latent time. It will be remembered that latent time, before the rise of the galvanometer wave, was estimated by us to vary in normal persons between two and five seconds. In fact, the normal average is three seconds for first series, and 3·77 seconds for subsequent series. In the following tables, one relating to latent space on the kymograph, and the other to latent time, only seven of the eleven cases of dementia præcox appear, for in the others the waves were so slightly marked or so uncertain that the facts could not be satisfactorily determined. One of these patients (Dr.

S.) was tested with both the mixed series and a series of word associations.

Latent Time in Millimetres of Distance from Stimulus to Beginning of Ascent of Galvanometer Emotional Wave in Cases of Insanity.

Names and Diagnosis.	Miss S. Dementia paranoides.	Dr. S. Dementia paranoides.	Dr. S. Word association.	Sp. Chronic katatonia.	A. V. D. Chronic katatonia.	F. Chronic katatonia.	J. Acute katatonia.	M. Acute katatonia
Series I.	3·13	3·75	4·01	3·2	2	4·77	7·16	24·25
Series II.	2·66	3·87	5·81	...	5	5·5	17·3	
Series III.	3·93	4·22						
Series IV.	...	5·46						

Latent Time in the same Cases of Insanity as above Estimated in Seconds.

Names and Diagnosis.	Miss S. Dementia paranoides.	Dr. S. Dementia paranoides.	Dr. S. Word association.	Sp. Chronic katatonia.	A. V. D. Chronic katatonia.	F. Chronic katatonia.	J. Acute katatonia.	M. Acute katatonia.
Series I. mixed stimuli	3·47	4·16	4·45	3·55	2·22	5·3	7·95	26·94
Series II.	2·93	4·3	6·45	...	5·55	6·11	19·22	
Series III.	4·36	4·68						
Series IV.	...	6·06						

In the first case, a woman with dementia paranoides, the latent time is quite within normal boundaries. In the second case, also dementia paranoides, Dr. S., the normal was overstepped only in the fourth round of the same mixed series, but with the same patient with a word association, the latent time was excessive (6·45) in the first repetition of the same words. In the third case, (Sp.), a case of chronic katatonia, the first series showed a latent time of 3·55 seconds, but there were no waves whatever in the repetitions. The four succeeding patients, all cases of kata-

tonia, show increase of latent time, and the two acute cases of katatonia presented an astonishing interval of space and time between the stimulus and the galvanometer wave.

The following table will better show the differences in latent time between the normal and cases of dementia præcox, especially in the averages given at the end of the table.

Comparative Table showing Latent Time in Galvanometer Curve of Normal Cases and of Dementia Præcox.

										Average.	Average of distribution.
Normal	Series I.	2·28	2·05	3·5	4·5	3·27	2·51	...	...	3·01	·73
	Series II. and III.	2·83	1·95	4·88	5	4·44	3·94	2·57	4·6	3·77	·99
Dementia Præcox	Series I.	3·47	4·16	4·45	3·55	2·22	5·3	7·95	26·94	7·25	5·09
	Series II. and III.	2·93	4·3	6·45	5·55	6·11	19·22	4·36	4·68	6·70	3·13

The average of distribution is obtained by subtracting the ordinary average from the larger numbers in the series, or the smaller numbers from the average. The sum of these differences is divided by the number of items, which gives what is called the average of distribution or the average of differences—a useful method of showing wide fluctuations in pathological conditions.

Chapter V.—Association Experiments.

Galton, Wundt, Kraepelin, Aschaffenburg, Sommer and others, have introduced into psychology a very simple experiment, consisting of the calling out of a word to the test person, who must respond as quickly as possible with the first word that occurs to him. The reaction time between the stimulus word and the response, can be measured with a one-fifth second stop watch. It was originally expected that this method would reveal certain intellectual differences in

various individuals. But from the results of investigations carried out in the Psychiatric Clinic at Zürich, it has been found that it is not intellectual factors, but the emotions that play the chief part in determining these associations.

Two persons, of the same social plane, one intelligent, the other unintelligent, even with differences in the character of their intellectual development, may still produce similar associations, because language itself has many general word connections which are familiar to all sorts of individuals belonging to the same circle of society.

There are certain well-marked differences between the word associations of educated and uneducated persons. For instance, the uneducated prefer inner connections with deeper meaning, while the educated very often select simply superficial and linguistic associations. This difference depends, as has been ascertained at the Zürich Clinic, upon the fact that the uneducated fix their attention more closely than the educated upon the actual meaning of the stimulus word. But attention, as has been shown by Bleuler, is nothing more than an emotional process. All affective processes are more or less clearly connected with physical manifestations, which are also to be observed in conjunction with attention. It is therefore to be expected that the attention roused by every association should have an influence upon the galvanometer curve, though this is but one of the affective factors represented in an association experiment.

We observe, as a rule, considerable variation in reaction time, even with practised and quick test persons. One is inclined to explain such irregularities, which are apparently accidental, by supposing the stimulus word to be unusual and difficult, or that the attention is momentarily relaxed for some reason or another. Such may at times be the case, but these reasons are not sufficient to explain the frequent repetition and long duration of certain reaction times. There must be some constant and regular rule to account for them. This disturbing factor has been found at the Zürich Clinic to be in most cases some characteristic thought complex of intrinsic importance for the personality of the test person. The following series will illustrate our meaning :—

Stimulus word.	Reaction word.	Reaction time.
Head	Hair	1·4
Green... ...	Meadow ...	1·6
Water... ...	*Deep*	*5*
Stick	Knife	1·6
Long	Table	1·2
Ship	*Sink*	*3·4*
Ask	Answer ...	1·6
Wool	Knit	1·6
Spiteful ...	Friendly ...	1·4
Lake	*Water* ...	*4*
Sick	Well	1·8
Ink	Black... ...	1·2
Swim	*Can swim* ...	*3·8*

The four italicised numbers are abnormally long reaction times. The stimulus words are quite ordinary, not difficult, and are such as commonly carry numerous current connections. By questioning the patient, we learn that recently, when greatly depressed, he had determined to commit suicide by drowning. *Water*, *lake*, *ship*, *swim*, were words that excited this complex. The complex brought about lengthening of the reaction time. This phenomenon is quite usual, and is to be observed constantly and everywhere in association studies. Lengthened reaction time may therefore be regarded as a complex indicator, and be employed for the selection from a series of associations of such as have a personal significance to the individual. It is self-evident that associations of this kind are apt to be accompanied by lively emotional tone. The explanation would be simple if the test person were always conscious of the complex which had been excited. But it is extraordinarily common for the test person to be unconscious of the complex disturbed by the stimulus word, and to be unable to answer questions relating to it. It is then necessary to employ the psycho-analytic method, which Freud uses, for the investigation of dreams and hysteria. It would carry us too far to describe here the details of this method of analysis, and readers must be referred to Freud's works [4].

The cause of the interference with the reaction must be sought for in the strong emotional tone of the complex.

Individuals with good powers of introspection often affirm that they could not respond quickly, because of the sudden crowding into consciousness of a number of words among which they could find none suitable for the reaction. This is easily understood, for strong affects always collect numerous associations around them, and, on the other hand, an assemblage of associations is always accompanied by an intense emotional tone. In some cases we have an opposite condition from the above, and the test persons are not able to react because of a vacuum in consciousness, in which event the complex hinders reaction by simply not appearing in consciousness. Thus the underlying thought complex sometimes carries too much into consciousness, and at other times too little, in either case disturbing the uniform flow of psychic functions. It acts like a peace-breaker in the psychic hierarchy. Such being the behaviour of the complex under normal conditions, it is easy to understand how it may play the chief part in abnormal mental states based upon disordered affectivity.

Lengthened reaction time is not the only index of a complex. If the stimulus word causes a sudden embarrassment and brings out some striking and unusual reaction-word, it is certain that a complex has been struck, so that any reaction out of the ordinary may also be regarded as indicating the presence of an emotional thought complex.

It is not infrequent to observe a lengthened or disturbed reaction also in the second reaction after some critical stimulus word, so that we have a persistence of the affect to the next following reaction, a fact which also may be taken to indicate the existence of a complex.

And, finally, we have in the method of reproduction another excellent aid for the discovery of the complex. When the series of stimulus-words has been finished, the list is gone over again, and the test person simply asked to repeat the word he had given before in response to the stimulus. We then notice that where stimulus-words touched upon a complex, the memory plays false and the test person tends to react with some other word than the one first given. This paradoxical phenomenon depends altogether upon the

influence of a strong emotional tone. The complexes are often unpleasant and create a natural resistance in the individual; but they are not always unpleasant or painful, and even with such complexes as the test person would be perfectly willing to reveal, there is yet an inhibition present which shows itself in like manner. The cause of defective reproduction must lie in the general nature of the complex as already described, in a certain independence of the complex, which comes and goes according to factors peculiar to it, and not at the behest of consciousness, and which yields the self-generated associations, and not such as are sought by consciousness. We, that is, our conscious selves, are on the whole in a sense the resultants of competitions in the unconscious.

It is thus that affective factors present themselves everywhere in our associations; and it is of interest to ascertain whether the psycho-galvanic reflex runs a parallel course with the complex indices just described; whether it does so regularly or has a preference for certain constellations; whether differences exist when a complex is conscious or unconscious, &c.

Wherever possible, we have employed the pneumograph at the same time with the galvanometer in these association studies to determine whether parallel disturbances were present.

The association question is many-sided, and there are numerous methods by which to study it. We shall try in the following pages to present our method and to confine ourselves more especially to our method of investigation, rather than to bring forward too prominently results which, owing to the small number of individuals examined, have simply a casuistic value, and cannot be looked upon as having general application.

§ 1.—*The Results Obtained with Association Tests.*

(1) When the experiment is ended we measure the heights of the galvanometric curves and arrange them in a table, with other results of the tests, as follows:—

Case I.—Uneducated man, aged 40, normal, two series of word associations, each twenty-four words. (Nine words given as example.)

	Series I.				Series II.		
No.	Height of galv. curve in mm.	Reaction time one-fifth sec.	Association.	Reproduction.	Height of galv. curve in mm.	Reaction time one-fifth sec.	Reaction.
1	9	9	Table—chair	ditto	7	7	ditto.
2	4	9	Sit—on a chair	ditto	3	15	ditto.
3	4	11	Garden—vegetable ...	ditto	3	6	ditto.
4	3	14	Red—apple	ditto	4	5	ditto.
5	3	9	Write—with pencil ..	ditto	4	7	ditto.
6	6	40	Full (no reaction)	...	2	6	cas[illegible]
7	3	8	Good—sugar	...	9	9	apple.
8	6	6	Forest—wood	ditto	4	5	ditto.
9	5	10	Tavern—drink	ditto	2	5	ditto.

As shown in the table, we made one repetition of the experiment in this instance; in other cases two repetitions were made.

(2) We then determine the arithmetical average of the galvanometric deviations, which in this instance is 4·9 mm. These figures are naturally only relative and, with our apparatus, correspond to only one-half of the actual movement of the mirror of the galvanometer. (The actual figure would be 9·8 mm.).

(3) We then determine the probable average (Kraepelin) of the reaction times in the following manner: The figures are arranged in a column in the order of their size, and the middle number is taken, which in this instance is 1·8 seconds. The probable is here preferred to the arithmetical average, because occasionally very high numbers occur in such tests, where the reaction times are so much more liable to increase than diminution. An arithmetical average would

be unduly influenced by the occasional presence of one or more large numbers, and would not give us the actual average of the reaction time.

(4) In the second series the average of the galvanometer deviations was 4·8 mm., and that of the reaction times 1·2 seconds. We observe, therefore, a reduction in the average height of the galvanometer curve, which is clearly due to lessening of the power of the stimulus in the repetition. The same phenomenon is also seen in the average of the reaction times, which is shortened. The fact that every reaction is accompanied by a galvanometer movement is due to the emotion of attention which accompanies each reaction and is great enough to produce notable physical changes.

(5) We note that in the second series certain associations (the sixth and seventh) are repeated with a change of words. These defective or changed reproductions indicate that the psychological constellation for the respective associations had changed in the short time (a little over one half hour) that had elapsed since the first series had been given. We know that associations which belong to certain complexes are those that may, because of inner conditions, suffer change within a short period of time. We may, therefore, expect that such false reproductions carry with them particular emotional phenomena; and this is actually here the case. The arithmetical average of the altered reproductions is 5·7 mm., while in the first series the average for the same associations was 4·5 mm. Furthermore, the altered reproductions in the second series show an excess of some ·8 mm. over the average of the stimulation of the first series. The average of the reaction times for the altered reproductions is 1·2 seconds, and for the correct reproduction 1 second, as would be expected. We learn from this that the supposition that the altered reproductions are affective phenomena would seem to be justified. We will not here enter into details in relation to the psychoanalysis of such manifestations, as we do not wish to forestall an especially careful study of this question now being made in this clinic by Dr. Binswanger.

(6) From the above consideration one would also expect that those associations which are changed in the repetition should also present some sort of affective signs in the first series; but, contrary to our expectation, we see in this case that the average height of the galvanometer deviation for the words subsequently changed in repetition is 4·8 mm., while the average for the unaltered reproductions is 5 mm. This difference is, of course, small, and no particular deduction could be drawn from one case. It is to be noted that the reaction time (average) for the associations subsequently wrongly reproduced is 1·9 seconds, and for the words correctly reproduced 1·8 seconds. Perhaps there is here a slight indication of the phenomenon to which we refer.

(7) In the preceding paragraphs we have frequently intimated that there is a certain connection between affectivity and the length of reaction time, and this has been already carefully determined in the work of one of us (Jung [6]). One may expect to have, as a rule, large galvanometer curves with long reaction times, always, however, with the limitation that such lengthened reaction times only are considered which are connected with associations that directly excite complexes, and not the long reaction times which may follow immediately after reactions which excite complexes. These latter are frequent as examples of perseveration. In order to discover the actual complex-exciting association it is necessary to employ the psycho-analytic method, and for this purpose a more suitable material is needed than is at our disposition. We, therefore, content ourselves here with simply determining the average height of all galvanometer curves in relation to reaction times which lie respectively above and below the probable average.

In Series I. the average galvanometer curves connected with long reaction times is 4·5 mm.; and with short reaction times 6·1 mm.

In Series II. the galvanometer curves with long reaction times average 5·7 mm.; and with short reaction times 4·4 mm.

The two results are contradictory. The cause of this

lies in factors already alluded to and in other difficultiès which must be the subject of later study.

(8) The alteration of the psychological constellation of Series II. already mentioned may be manifested in the galvanometer curve alone, without any change in the reproductions. This matter might be thus explained. In the first trial only certain meanings are attached to the stimulus word by the test person, *i.e.*, not all of the associations belonging to it are excited at the first trial, while at the second trial another series of new connections may be aroused. We very often meet this phenomenon in our psycho-analytic investigations.

It is of the greatest importance for the individual and his intellectual processes to know how his associations are presented to consciousness, whether he has quick and complete command of all related associations. This point is of the utmost value for tests of the intelligence, since many persons may appear to be stupid during investigation because their associations are not at immediate command, and on the other hand stupid persons may seem to be relatively intelligent simply because they have good command of their associations. We may perhaps also expect by this means to discover important differences between educated and uneducated intellects, and the galvanometric experiments seem to open to us endless vistas.

In this case 41·6 per cent. of the associations in Series II. show an increased galvanometric curve with an average plus difference of 2·3 mm. It is possible that later investigations may show us that this result has considerable psychological significance for the individual, because this test person was quite unintelligent.

(9) We observe frequently after a marked galvanometric deviation, that there is an inclination to successive large curves, if the succeeding stimuli are not too quickly given. This is not unexpected because it is a general psychological experience that strong affects induce great sensitiveness (see Jung [6]). If therefore we take the average of the curves which follow unusually strong galvanometer curves and compare them with the arithmetical average of all the

curves, we find that after unusually high curves, the average height in Series I. is 5 mm. and the reaction time two seconds in contrast with the general averages of 4·9 mm. and 1·8 seconds. In Series II. these figures are reversed, for here the average has a plus difference of ·6 mm. while the average of the reaction times shows a minus difference of ·5 seconds. The relations are not quite definite.

(10) The whole of Series I. shows a rather uniform course, for the average of distribution amounts only to 1·6. The deviations are relatively not very high. The highest curve is 12 mm., and the association connected with it is

Stupid—am I

which was for this individual a clear ego-centric stimulus which evidently struck a strong emotional complex.

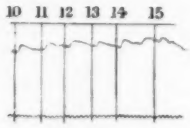

FIG. 12.

Portion of curve in word-associations of a normal test-person.

FIG. 13.

Portion of curve corresponding to the word-association "Stupid—am I."

Fig. 12 is a portion of the curve in this case. In this, one notes the even course and uniform emotional value of each association. The accompanying pneumographic curve is undisturbed.

Fig. 13 shows the portion of the curve in which the association *stupid—am I* (reaction No. 18) occurred. This portion is marked by a very high many-pointed wave. The pneumographic curve is altered here, as it is also in reaction No. 19, though the latter has little emotional tone. But No. 19 has,

however, a very long reaction time (4·8 secs.), which is to be looked upon as a persisting intellectual disturbance from reaction No. 18. We observe here one of the numerous instances where the pneumographic curve and the reaction time show evident disturbances, while the galvanic curve is unaffected. According to our hypothesis, this is owing to the fact that the galvanometer indicates only acute affective conditions, and not the more lasting intellectual after-effects, these latter being often well registered by reaction time and pneumograph. The reaction time shows how long the mind requires to detach itself from its conscious or unconscious pre-occupation, and turn to the new stimulus. The respiration, because of its close relation to consciousness (susceptibility to voluntary influences), is also affected by intellectual processes, while the galvanometer seems to be influenced directly only by the unconscious.

Case 2.—*Uneducated but rather intelligent man, aged* 38.

(1) We have arranged in the following table the results of three series of associations of twenty-four words each :—

Series I.	Arithmetical average of galvanometer curves	5·6 mm.
Series II.	Arithmetical average of galvanometer curves	7·2 mm.
Series III.	Arithmetical average of galvanometer curves	5·9 mm.
Series I.	Probable average of reaction times ...	1·8 sec.
Series II.	Probable average of reaction times ...	1·3 sec.
Series III.	Probable average of reaction times ...	1·0 sec.

The reaction times are what we expect, but the galvanic curves show an unexpected increase in the second series. Our first supposition would be that this is owing to some physical change ; for instance, better contact from increased warmth of the hands, or a change of posture of the body that increased the pressure of the hands upon the electrodes. Such conditions may not only interfere with the experiment, but also render comparison of results difficult. But it is also possible that the psychological constellation changed in the second series, causing thereby greater deviation of the galvanometer. If we take the first fifteen curves of Series II., we find the average to be 4·7 mm., which is much less than the average of Series I. But if we take the last nine curves of Series II., we find the average to be 11·3 mm., and that the

cause of the great difference lies where the principle of loss of power in repeated stimulation does not seem to be effective. It is possible that after the fifteenth reaction there was a physical disturbance, which increased the height of the curves.

We find that the probable average of the reaction times of the first fifteen and last nine reactions both amount to 1·8 seconds, while the average of the galvanometer curves of the first fifteen reactions shows only a minus difference of 0·2 mm., as compared with the last nine curves. Now, if a physical change occurred toward the end of Series II., we might expect no change in the purely psychological reaction times. This is, however, not the case. For the increased galvanic curves in the last nine reactions correspond to an increase of the reaction times (1·4 seconds, as compared to 1 second of the first fifteen reactions). There is, therefore, a parallel between the galvanometer increase and the increased reaction times, from which we may conclude that the increase depends upon an altered psychological constellation.

We have already mentioned that a change in the constellation is owing to the arousing of complexes. The reactions occur in this wise :—

		Series I.			Series II.	
No.	Associations.	Reaction Time.	Gal. Curve.	Reproduction.	Reaction Time.	Gal. Curve.
1	Money—round	1·8 sec.	3 mm.	ditto	1·2 sec.	12 mm.
2	High—tree	1·4 sec.	7 mm.	ditto	1·4 sec.	4 mm.
3	Go out—morning ...	2·0 sec.	8 mm.	ditto	1·4 sec.	6 mm.
4	Floor—dirty	1·8 sec.	5 mm.	ditto	1·8 sec.	9 mm.
5	Wages—large	1·2 sec.	6 mm.	ditto	1·2 sec.	19 mm.
6	Pay—debts	3·4 sec.	9 mm.	ditto	3·0 sec.	15 mm.
7	Apple—red	2·4 sec.	5 mm.	ditto	1·4 sec.	27 mm.
8	Nurses—many	1·6 sec.	4 mm.	ditto	1·8 sec.	5 mm.
9	Five—small	1·8 sec.	5 mm.	ditto	1·2 sec.	5 mm.

While as a rule the reaction times are shortened in Series II., the galvanometer curves are higher. It seems as if the affects first really manifested themselves in Series II. after having been inhibited in Series I. As is shown, the largest increases are connected with the associations, "*money*—round, *floor*—dirty, *wages*—large" (the test person is an attendant or nurse and receives small wages), "*pay*—debts, *apple*—red, and *nurses*—many." It is easy to understand that five of these associations might arouse strong sentiments. The strong reaction with "apple red" is incomprehensible. But we have frequently noticed that quite indifferent associations following immediately upon strong emotional associations show in repetition sudden increase of galvanic reaction, as if the emotional tone were postponed. It is not impossible that we have such a phenomenon here, but we have no means of proving it. Affects are always inhibited if some other strong emotional complex displaces them. This was evidently the case here, because the unusual experiment excited the test person, so that he probably did not grasp the stimulus words in all their personal relations. In Series II. he was more quiet and could comprehend better, in consequence of which emotional tones were more easily developed than before. This phenomenon is theoretically very important, since it indicates how affects are repressed in normal persons. Inhibition of affects plays a powerful *rôle* in psycho-pathology. (See the works of Freud, Bleuler and Jung.)

This experiment also illustrates well that reaction time and galvanometer curve do not mean the same thing. We see here again how clearly the reaction time reveals a greater intellectual freedom than in Series II., whereas the galvanometer curves are considerably higher than those of Series I.

	Galv. curve.	Reaction.
(2) The altered reproductions of Series II. average	6 mm.	... 1·7 sec.
The altered reproductions of Series III. average	7 mm.	... 1·0 sec.
The unchanged reproductions of Series II. average	7·3 mm.	... 1·3 sec.
The unchanged reproductions of Series III. average	5·8 mm.	... 1·3 sec.

Here, too, the relations are somewhat obscure, which may be owing to the occurrence of very few altered reproductions. Only half of the above numbers coincide with our expectations.

(3) Galvanometer curves with long reaction times average in Series I. ... ... 6·4 mm.
Galvanometer curves with short reaction times average in Series I. ... ... 6·4 mm.
Galvanometer curves with long reaction times average in Series II. ... ... 8·1 mm.
Galvanometer curves with short reaction times average in Series II. ... ... 4·2 mm.
Galvanometer curves with long reaction times average in Series III. ... ... 6·8 mm.
Galvanometer curves with short reaction times average in Series III. ... ... 4·1 mm.

The first test is undecided, but the two following present figures which correspond with our expectation. (In Case 1 above recorded the first test also gave a contradictory result.)

(4) In Series II. 41·6 per cent. of the associations show an average plus difference of 3·2 mm. compared with Series I.

In Series III. 45·8 per cent. of the associations show a plus difference of 2·6 mm. as compared with Series II.

These figures prove, as already mentioned, that Series II. presents a considerably altered constellation. In Series III. there are still more psychological constellations changed. It is to be regretted that there was not a much larger material at hand for the farther investigation of matters so important for the psychology of the individual.

(5) Series I. Probable average of reaction times in associations with unusually high galvanometer curves ... ... 2·2 sec.
Series I. Arithmetical average of the corresponding galvanometer curves ... ... 5·2 mm.
Series II. Probable average of reaction times in associations with unusually high galvanometer curves 1·6 sec.
Series II. Arithmetical average of the corresponding galvanometer curves ... ... 12·0 mm.

Series III. Probable average of reaction times in associations with unusually high galvanometer curves	0·8 sec.
Series III. Arithmetical average of corresponding galvanometer curves	7·0 mm.

The curves in Series II. and III. do not, while those of Series I. do correspond to expectation. The reaction times in Series I. and II. are what we anticipate. Therefore, of six items, four coincide with our expectation.

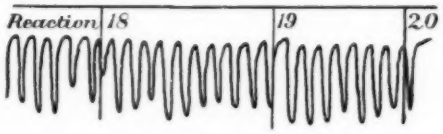

FIG. 14.

Portion of pneumographic curve in Case 2 (word-association, normal individual).[1]

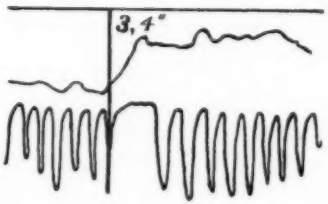

FIG. 15.

Galvanic and pneumographic curve corresponding to the word-association "pay—debts."[1]

(6) Series I. Presents in general a uniform character. The average of distribution is only 1·5 mm. The highest curve measures 9 mm., and this is connected with the association "pay—debts," which, as we have seen, also preserves its high emotional value in Series II.

[1] Fig. 14 and fig. 15 are reproduced the actual size of the tracing.

Series II. is much more irregular. The average of distribution is 3·8 mm., a very high figure, which well illustrates the general irregularity of the series. The highest curves of this series have already been described.

Series III. presents, on the other hand, another series with uniform character. The average of distribution is only 1·8 mm. The highest curve occurs with the association "wages—large," and amounts to 11 mm., and in Series II. it also had a high value. Such concord shows clearly that these figures are not accidental.

The pneumographic curve presents no peculiarities. In Series I., with indifferent associations, this curve has the aspect shown in fig. 14.

Fig. 15 is the galvanometric and pneumographic curve belonging to the association "pay—debts." In this we observe a marked inhibition of respiration during and after the critical association.

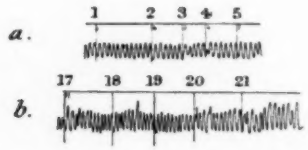

FIG. 16 (*a* and *b*).

(*a*) Respiratory curve, with word-associations No. 1 to 5 in Case 2.
(*b*) Curve, same case, associations No. 17 to 21.

The psychic excitation referred to previously in the last nine associations of Series II. seems to manifest itself also in the pneumographic curve, as apparently evidenced in figs. 16A and 16B.

Fig. 16A is a portion of the respiratory curve during associations 1 to 5. Fig. 16B represents associations 17 to 21. The difference is marked. We can hardly be mistaken in supposing that the change in respiration is the expression of a certain excitation, which is in harmony with our previous assumptions.

Case 3.—Uneducated man of moderate intelligence, aged 28, lively, excitable temperament. Normal. Three series of associations, each with twenty-three words.

(1) Series I. Arithmetical average of galvanometer curves ... ... 14·2 mm.
Series II. Arithmetical average of galvanometer curves ... ... 6·5 mm.
Series III. Arithmetical average of galvanometer curve ... ... 2·0 mm.
Series I. Probable average of reaction time ... 2·4 sec.
Series II. Probable average of reaction time ... 2·2 sec.
Series III. Probable average of reaction time ... 2·0 sec.

The curves of Series I. reach a considerable height, but the stimulus diminishes rapidly and intensely in power in the succeeding series.

The reaction times shorten uniformly, but are still in general somewhat long, as we observe not infrequently among emotional people.

	Galv.	Reaction time.
(2) The altered reproductions of Series II. average	7·9 mm. ...	2·0 sec.
The unchanged reproductions of Series II. average	1·8 mm. ...	2·2 sec.
The altered reproductions of Series III. average...	3·5 mm. ...	2·2 sec.
The unchanged reproductions of Series III. average	1·3 mm. ...	2·1 sec.

The galvanic curves correspond in both series to our expectation, but the reaction times in Series II. are contradictory, which, however, is changed if we do not employ the probable average (as is ordinarily done by us in all cases) but the arithmetical average, when the average time for altered reproduction is 2·8 sec., and for the unchanged only 2·4 sec.

(3) The galvanic curves with long reaction time in Series I. average ... ... 17·8 mm.
The galvanic curves with short reaction time in Series I. average ... ... 12·7 mm.

The galvanic curves with long reaction time in Series II. average	9·8 mm.
The galvanic curves with short reaction time in Series II. average	3·6 mm.
The galvanic curves with long reaction time in Series III. average	2·1 mm.
The galvanic curves with short reaction time in Series III. average	0·0 mm.

All of these figures are in perfect accord with our hypothesis.

(4) In Series II. 17·3 per cent. of the associations have an average plus difference of 5·8 mm.

In Series III. 17·3 per cent. of the associations have an average plus difference of 2·8 mm.

These figures show that the constellation in the latter series is not very much changed, with the exception of a few associations. We may conclude that all the strong emotional relations of the stimulus words were brought out in the first test. We should say here that Case No. 3 was well accustomed to this kind of experiment, while cases No. 1 and No. 2 were not.

(5) Series I. Probable average of reaction times following associations with unusually high galvanic curves	2·8 sec.
Series I. Arithmetical average of the corresponding galvanic curves	22·3 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	1·8 sec.
Series II. Arithmetical average of the corresponding galvanic curves	11·4 mm.
Series III. Probable average of reaction times following associations with unusually high galvanic curves	1·2 sec.
Series III. Arithmetical average of the corresponding galvanic curves	1·7 mm.

The galvanic curves are what we would expect in Series I. and II., but not in Series III. The reaction time is what we expect only in Series I.

	Galv.	Reaction time.
(6) Series I. Average of associations altered in subsequent reproduction	14·2 mm.	2·4 sec.
Series I. Average of association unchanged subsequently	13·5 mm.	2·0 sec.
Series II. Average of associations altered in subsequent reproduction ...	8·7 mm.	2·2 sec.
Series II. Average of associations unchanged subsequently	3·6 mm.	2·0 sec.

All of these figures coincide with what we expect.

(7) The general course of Series I. is very irregular. The average of distribution is 7·6, the highest number we have yet observed. In the tests with Cases 1 and 2 the various phases of stimulation were shown in strong, but much differentiated, emotions, but in this case with lively temperament there was a continual and marked fluctuation of emotions, and hence the high average of distribution.

Series II. is more uniform, and the average of distribution is 5·4, and in Series III. this average is only 2·3.

The highest galvanic curve in Series I. measures 51·5 mm. and is connected with the association " the sun—*burns.*" Why there should be here so strong a reflex innervation could not be understood without further examination. The test person himself could not explain why he had any particular emotion at this moment. But the connection was shown in the following associations. The other high curves (37, 21 and 18 mm.) occurred with the associations "*floor* — parquet," "*pay* — write," "*warm* — the stove." These three associations showed constant and similar disturbances in all three series, as illustrated in this table :—

	Series I.			Series II.			Series III.	
	Galv.	Reaction time.	Reproduction.	Galv.	Reaction time.	Reproduction.	Galv.	Reaction time.
Floor ...	37 mm.	3·0 sec.	ditto	13 mm.	3·2 sec.	ditto	2·5 mm.	3·0 sec.
Warm	18 mm.	1·2 sec.	ditto	31 mm.	2·2 sec.	ditto	7·0 mm.	2·0 sec.
Pay ...	21 mm.	2·0 sec.	ditto	4·5 mm.	0·8 sec.	ditto	7·5 mm.	2·2 sec.

All the reproductions were altered. With one exception all of the galvanometer curves were considerably above the averages for each of the series. As to the nine reaction times, four were above, and two coincided with the probable averages. It seemed justified from these observations to assume that a strong emotional complex lay behind them. But when questioned the test person answered that he had had no particular thoughts in connection with these reactions, and was evidently unconscious of any special complex. Yet even if a test person asserts that no complex is present, this is not conclusive in the face of so many indications pointing to interference by a complex. In this instance we distracted his attention from the matters in hand and asked what personal significance the word "floor" had for him, when suddenly he said with surprise and

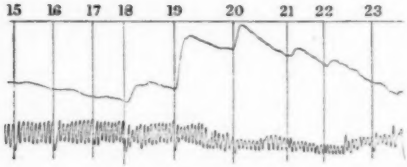

FIG. 17.

Portion of a curve to show emotional effect of certain word-associations.

embarrassment that recently a *stove* in his dwelling had become defective and *burned* the *floor* to such an extent that he had not only to *pay* for a new stove, but also for an entire new floor which was a hardship for him. Besides this there had been great danger from fire. Thus were all the disturbances above related perfectly explained, including the strong emotional tone of the association "the sun—*burns*."

We learn from this interesting episode that the galvanic phenomenon, like reaction time and alteration of reproductions, may give evidence of the existence of an unconscious complex. We cannot go into farther detail regarding this fact here, but the investigations of Dr. Binswanger already mentioned also throw much light on this subject.

The above described group of associations gives an unusually fine picture in Series II. of emotional effect upon the curves (fig. 17). At the beginning we have indifferent reactions. Reaction No. 18 is "floor," 19 "warm," 20 "wages—small," and 21 "pay."

The respiratory curve also shows the reactions very clearly. In general, inspiration is increased which is especially characteristic for this particular case in connection with expectant attention. The condition during the unconscious complex excitation seems therefore to have

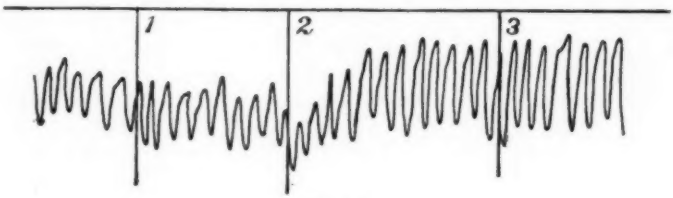

FIG. 18.

Expectation curve in Case 3.[1]

had a certain resemblance to the tension of expectation. An example of this tension of expectation in this case at the beginning of a test is shown in fig. 18.

Case 4.—*An educated woman, aged* 25, *used to these experiments. Three series of word associations, eighteen words in each.*

(*A*) Series I.	Arithmetical average of galvanic curves	6·8 mm.
Series II.	Arithmetical average of galvanic curves ...	1·9 mm.
Series III.	Arithmetical average of galvanic curves ...	0·9 mm.
Series I.	Probable average of reaction times	1·2 sec.
Series II.	Probable average of reaction times ...	1·0 sec.
Series III.	Probable average of reaction times ...	1·0 sec.

The galvanic curves show very rapid diminution, while the reaction time is very short and the lowest limit is soon reached.

[1] Fig. 18 is reproduced the actual size of the tracing.

	Galv.	Reaction time.
(*B*) The altered reproductions of Series II. average	7·5 mm. ...	1·6 sec.
The unchanged reproductions of Series II. average	1·6 mm. ...	1·0 sec.
The altered reproductions of Series III. average	0·0 mm. ...	1·0 sec.
The unchanged reproductions of Series III. average	1·0 mm. ...	1·0 sec.

The result in Series II. is what we expected, but this is not true of Series III., perhaps because only very few altered reproductions occur.

(*C*) The galvanic curves with long reaction times in Series I. average	11·6 mm.
The galvanic curves with short reaction times in Series I. average	5·2 mm.
The galvanic curves with long reaction times in Series II. average...	5·4 mm.
The galvanic curves with short reaction times in Series II. average...	0 8 mm.
The galvanic curves with long reaction times in Series III. average	1·0 mm.
The galvanic curves with short reaction times in Series III. average	1·5 mm.

The figures in Series I. and II. are what we expected, but not in Series III., perhaps because most of the curves had already sunk to zero.

(*D*) In Series II. 5·5 per cent. of the associations show an average plus difference of	6·0 mm.
In Series III. 11·1 per cent. of the associations show an average plus difference of	2·7 mm.

In this case also we note a great readiness of the association to appear fully on the first stimulus, so that the constellation does not change much later on.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanometer curve...	1·1 sec.
Series I. Arithmetical average of corresponding galvanometer curves	6·5 mm.

Series II. Probable average of reaction times following associations with unusually high galvanometer curves ... ... 1·0 sec.
Series II. Arithmetical average of corresponding galvanometer curves ... ... 1·2 mm.

The figures in Series III. are omitted, because most of the galvanic curves were reduced to zero. The figures given in the above two series do not accord with our expectation.

	Galv.	Reaction time.
(*F*) Series I. Average of associations altered in subsequent reproductions	4·3 mm. ...	4·0 sec.
Series I. Average of associations unchanged subsequently	4·4 mm. ...	1·2 sec.
Series II. Average of associations altered in subsequent reproductions ...	6 mm. ...	1·2 sec.
Series II. Average of associations unchanged subsequently	1·6 mm. ...	1·0 sec.

These figures are what we should expect.

(*G*) Average of distribution in Series I. ... 5·5
Average of distribution in Series II. ... 2·2
Average of distribution in Series III. ... 1·6

We find as usual the greatest variation in the figures in the first series. With lessening power of the stimulus in the repetitions a levelling tendency is manifested as regards this variation in the power of the stimulus.

The highest curves are found in the following associations:—

	Series I.		Series II.			Series III.		
	Galvanometer.	Reaction time.	Reproduction.	Galvanometer.	Reaction time.	Reproduction.	Galvanometer.	Reaction time.
Ball—dance	4·3 mm.	4·0 sec.	0	7·5 mm.	1·6 sec.	ditto	12 mm.	0·8 sec.
Dress—red ...	9 mm.	1·8 sec.	ditto	2· mm.	0·6 sec.	ditto	0 mm.	0·8 sec.
Pretty—ugly	7·5 mm.	1·4 sec.	ditto	3· mm.	0·8 sec.	ditto	3 mm.	1·2 sec.

The galvanic curves are much higher than the average in all three series for the association "ball-dance." The intensity of the affect here is shown by the fact that while fifteen out of eighteen reactions in the last series caused no deviations of the galvanometer, this particular association induced a deflection of 12 mm. In this instance the test person expected in a few days to go to a fancy dress ball, but despite much search had not yet found a suitable costume. She was, therefore, in a state of anxiety concern-

FIG. 19.

Word association "ball—dance" in Case 4.

ing it. The association "dress" and "pretty" are self-evident.

The reaction times were rapidly shortened in the repetitions, because of her natural aptitude in speech. It is evident that at times the galvanic phenomenon is more helpful than lengthened reaction times in demonstrating emotional states.

Fig. 19 is a curve from Series III. in this case representing the well-marked association "ball-dance." Repetition of the association test is to be recommended when one desires to bring out more clearly very strong emotional complexes.

§ 2.—*Résumé of the Tests with Word Associations in Normal Individuals.*

Our limited material, consisting of the word associations in one educated woman and three uneducated men leads us to bring forward with much reserve a *résumé* of our results. We know that they must be regarded as only preliminary, and as being of questionable value, but at the same time they foreshadow features of interest for future enquiry and investigation. Our intention in this work is chiefly to point out indications, and our presentation of results must be taken in this sense.

(1) The average plus difference of a galvanic curve, produced by an association whose reaction time exceeds that of the probable average of the same series, is 2·7 mm.

Taking into consideration the above-mentioned limitations this figure seems to express that in certain cases there is a clear parallelism between the length of reaction time and the height of the galvanometer curve. This method appears, therefore, to afford a psycho-physical proof of the hypothesis of one of us (Jung [6]), that very long reaction times are affective phenomena.

(2) Altered reproductions show an average plus difference of 2 mm. over unchanged reproductions.

(3) Such associations as are changed in the reproductions of the following series present an average plus difference of 6·8 mm. over such as are reproduced subsequently unchanged.

These two figures, especially the last, seem to offer a psycho-physical confirmation of the hypothesis of one of us (Jung [6]), that altered reproductions are affective phenomena.

The remaining methods embodied in the text of our work have little right to a special summing up here, because of the scantiness of our material, and also because of some contradictions in our results.

§ 3.—*Word Associations in Dementia Præcox.*

There were but two of our cases of paranoid dementia that could be used for a test of word associations with the galvanometer.

Case 1.—*Male, aged* 36, *very intelligent, academic education. Speech well preserved. Two series of associations, with twenty-four words each.*

(*A*) Series I. Arithmetical average of heights of galvanometer curve	11·6 mm.
Series II. Arithmetical average of heights of galvanometer curve	4·6 mm.
Series I. Probable average of the reaction times...	6·6 sec.
Series II. Probable average of the reaction times...	4·8 sec.

The average height of the galvanometer curves falls in both series within normal limits, which is not the case with the reaction times, which show excess. Our four normal test persons presented the following average :—

Series I. Galvanometer curves 7·8 mm. Reaction times 1·8 sec.
Series II. Galvanometer curves 5·1 mm. Reaction times 1·4 sec.

From these figures it is seen that the patient offers a strong contrast in the length of the reaction times.

	Galv.	Reaction Time.
(*B*) The altered reproductions in Series II. average	4·7 mm.	6·0 sec.
The unchanged reproductions in Series II. average	3·4 mm.	2·8 sec.

These figures coincide with the normal, and are what we would expect. But we note that the unchanged reproductions present a much lower value in the reaction time than the altered reproductions.

(*C*) The galvanometer curves with long reaction times in Series I. average	13·1 mm.
The galvanometer curves with short reaction times in Series I. average	10·3 mm.
The galvanometer curves with long reaction times in Series II. average	3·8 mm.
The galvanometer curves with short reaction times in Series II. average	4·0 mm.

In this table the figures in Series I., but not in Series II., are what we expect.

(*D*) In Series II. 12·5 per cent. of the associations show an average plus difference of 4·5 mm.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanic curves	4·0 sec.
Series I. Arithmetical average of the corresponding galvanic curves	10·0 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	7·6 sec.
Series II. Arithmetical average of the corresponding galvanic curves	3·2 mm.

In this table, only the reaction time of Series II. is in accordance with our expectation.

	Galv.	Reaction time.
(*F*) Series I. The associations with altered reproductions in the following series average	9·8 mm. ...	6·6 sec.
Series I. The associations with unchanged reproductions in the following series average	13·5 mm. ...	5·4 sec.

Only the reaction time here is what we expect.

(*G*) The average of distribution in Series I. was 5·8.

The average of distribution in Series II. was 3·4.

These figures are similar to those of Case 4 among the normal.

The highest galvanic curve occurred with the reaction "love—a psychic process" (30 mm.), and here was also the longest reaction time (27·2 sec.). The next highest curve was connected with the reaction "*wife*-marriage-law" (29 mm.). The patient is single, and having had with "love" a strong emotional tone, it was not surprising that "wife" should also evince a similar intensity. Another high curve was found in the association "*sick*-at-heart" (26 mm.). The patient still had some insight into his condition, and knew that he was confined in the asylum because of his mental malady, hence the strong emotion connected therewith. The word "handsome" produced a curve of 25 mm. The patient is very vain, and pays extraordinary attention to his dress. The contents of the association present the symptoms of affectation, which is evident from his external appearance. Most of his associations showed a definition character which, in educated people, always indicates a certain amount of affectation. The following are examples :—

Write—Activity.
Shoes—Footwear.
Hat—An article of clothing.
House—Building construction.
To sit—Condition of rest.
Money—Medium of exchange.
Proud—Adjective.

The long reaction times may be due to this affected manner of expression, though this can hardly be the only cause.

Case 2.—Woman, single, aged 62, uneducated, medium intelligence. Speech mingled with neologisms. Three series of associations with twenty-five words each.

(*A*) Series I. Arithmetical average of the galvanic curves ... ... 7·9 mm.
Series II. Arithmetical average of the galvanic curves 3·6 mm.
Series III. Arithmetical average of the galvanic curves 2·5 mm.
Series I. Probable average of reaction times... ... 10·8 sec.
Series II. Probable average of reaction times ... 6·4 sec.
Series III. Probable average of reaction times ... 6·0 sec.

As in the former case, the galvanic deviations are of medium height, while the reaction times are extraordinarily long.

	Galv.	Reaction time.
(*B*) The altered reproductions in Series II. average	3·6 mm. ...	6·6 sec.
The unchanged reproductions in Series II. average	3·6 mm. ...	5·2 sec.
The altered reproductions in Series III. average	2·5 mm. ...	7·4 sec.
The unchanged reproductions in Series III. average	2·4 mm. ...	4·6 sec.

The reaction times accord with our expectation, as in the former case, much better than the galvanometer curves.

(*C*) The galvanometer curves with long reaction times in Series I. average... ... ... 9·6 mm.
The galvanometer curves with short reaction times in Series I. average ... ... 6·0 mm.
The galvanometer curves with long reaction times in Series II. average ... ... 4·7 mm.
The galvanometer curves with short reaction times in Series II. average ... ... 2·6 mm.
The galvanometer curves with long reaction times in Series III. average ... ... 2·8 mm.
The galvanometer curves with short reaction times in Series III. average ... ... 2·5 mm.

The figures in all three series are what we expect.

(*D*) In Series II. 28·0 per cent. of the associations show an average plus difference of 4·7 mm. In Series III. 24·0 per cent. of the associations show an average plus difference of 4·8 mm.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanic curves	11·6 sec.
Series I. Arithmetical average of corresponding galvanic curves	11·8 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	5·8 sec.
Series II. Arithmetical average of corresponding galvanic curves	3·7 mm.
Series III. Probable average of reaction times following associations with unusually high galvanic curves	8·0 sec.
Series III. Arithmetical average of corresponding galvanic curves	2·5 mm.

Twice the reaction times are what we expected, the galvanic curves only once, and in Series III. the arithmetical average is the same.

	Galv.	Reaction time.
(*F*) Series I. The associations with altered reproductions in the following series average	9·0 mm. ...	10·4 sec.
Series I. The associations with unchanged reproductions in the following series average	6·3 mm. ...	12·4 sec.
Series II. The associations with altered reproductions in the following series average	3·3 mm. ...	6·6 sec.
Series II. The associations with unchanged reproductions in the following series average	4·0 mm. ...	4·8 sec.

We find in this table that only the galvanic curves in Series I. and the reaction times in Series II. are what we expected.

(*G*) The average of distribution in Series I. was 4·9.
The average of distribution in Series II. was 2·8.
The average of distribution in Series III. was 1·6.

The highest galvanic curve (21 mm.) is found in the association "sun—sun-time," and here the reaction time is 14·0 seconds. It is difficult to explain this excessive deviation. The preceding association is "stout—constitution" (15 mm., and 14·8 seconds reaction time). The patient is very stout, which she thinks due to supernatural influences. She complains much of this "forced" disfigurement. In Series II. these two associations caused no deviations, but in Series III. "stout—constitution" suddenly induced the largest deflection of the whole series, viz., 14·5 mm., whereas the average was only 2·5 mm. There was a curve of 20 mm. with the association "ugly—disfigured by great suffering," and with this a reaction time of 12·0 seconds. The contents of this association are concerned with the same theme as "stout—constitution." Another high curve occurred with "high—highest action" (19 mm. and reaction time 11·2 seconds). This association was subsequently altered twice in the reproductions. It is connected with the delusion of the patient that she had accomplished the "highest work."

The associations are typically affected and show a distinctly morbid character.

The following are examples :—

Diligent—High esteem—Payment.
Love—To be lovable—Wedding.
Snake—To point out as extraordinary.
High—Highest action—Highest distinction.
Ugly—Disfigured by great suffering.

Résumé : In our tests with word associations in the two cases of dementia præcox the only striking fact has been the great lengthening of reaction times. In the relations between the galvanometer curves and associations we have found nothing different from the normal. From the material of Jung, who has analysed a large collection of association experiments in dementia præcox, we learn that in by far the greater proportion of these cases there is no particular lengthening of reaction time. Therefore a long reaction time cannot be considered as characteristic for all cases

of dementia præcox. It is of value in some cases. It is only present when the patients suffer from certain hindrances to thought, which are often present in this disease.

When we examine the associations of such patients we find that the hindrance to thought (lengthened reaction time) is especially manifested where complexes constellate the association, which is also the case in normal individuals. This phenomenon first led Jung to think that the specific pathological factor in dementia præcox depends upon some complex. A complex in fact plays a great *rôle* in the associations of our two patients here described. The reaction times are extraordinarily long where connected with a complex. The complex constellations are also very numerous, as well as the altered reproductions related to them. In our normal cases we found an average of 30 per cent. of altered reproductions in Series I., while the patients had 51 per cent. Besides this, the character of the associations presents abnormalities almost constantly, especially around the complexes.

From these indications we may conclude that little of a pathological nature can be found in the general and regular mechanisms of thought, but rather in the manner and method of reaction of the individual to his complexes. We find in both of these patients an increased influence of the complex upon association, which corroborates the results of innumerable analyses of dementia præcox by Jung. This phenomenon has an important and general clinical significance, because, when carefully analysed, nearly all the symptoms are found to be determined by an individual complex, often manifested in a very convincing way. This is particularly true for delusions and hallucinations. A series of other symptoms is more often dependent upon indirect disturbance of association by the complex. This state of affairs explains why we do not discover any elementary disturbances, even in quite intense mental disorder; the dementia is shown only in the most delicate psychological relations. Therefore we shall look in vain, for the present and for a long time to come, among these patients for simple, elementary disturbances common to all cases.

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Note.—Since this article was put into type we have found that Féré [3], carrying a current through a test person with various sensory stimuli, made the following observation: "Il se produit alors une déviation brusque de l'aiguille du galvanomètre . . . . La même déviation se produit encore sous l'influence d'émotions ethéniques c'est à dire qu'elle se produit dans toutes les conditions ou j'ai signalé précédemment une augmentation de volume des membres mise en évidence par le pléthysmograph." This clearly shows that Féré made the discovery two years before Tarchanoff.

THE FUNCTIONS OF THE TRIGEMINAL NERVE.[1]

BY H. MORRISTON DAVIES, M.C., F.R.C.S.

INTRODUCTION.

THE material on which this paper is founded is partly clinical and partly experimental. The clinical material is of two kinds: (1) The results of personal examination of thirty cases in which the Gasserian ganglion had been removed. The examination of some of the patients was repeated several times and at various periods from nine days up to seven years after the operation; in some cases the interval between the first and final observations was more than one year, and in one case it was over a year and a half. (2) The use of notes and the results of correspondence with patients in twenty further cases in which the Hartley-Krause operation had been performed.

In three cases the roots of the Gasserian ganglion were stimulated during the course of the operation for trigeminal neuralgia. This was suggested by Sir Victor Horsley, and was carried out as a means of ensuring complete removal of the ganglion.

The experimental evidence is based on certain experiments made on animals by Sir Victor Horsley.

I have been able to make use of fifty cases; forty-eight of these were operated on by Sir Victor Horsley and two by Mr. Bucknall. I take this opportunity of expressing my gratitude to these gentlemen for permission to use the material, and to the former for constant encouragement and advice throughout the course of this investigation.

[1] The greater part of this paper formed the thesis presented for the degree of M.D. (Cantab.).

The subject matter of the paper has been collected under the following headings:—

(1) Distribution of the fifth nerve to the skin of the face: (*a*) Anæsthesia determined with the camel's-hair brush. (*b*) Pressure-touch anæsthesia; analgesia; thermal anæsthesia. (*c*) Paræsthesiæ.

(2) Distribution to the external auditory meatus and the membrana tympani.

(3) Distribution to the mucous membranes.

(4) Distribution to the deep structures: (*a*) to the dura mater; (*b*) to the subcutaneous parts of the face; (*c*) muscle sense.

(5) Distribution to the organs of special sense: (*a*) taste; (*b*) smell; (*c*) hearing; (*d*) vision.

(6) Motor distribution: (*a*) muscles of mastication; (*b*) vaso-motor and secreto-motor.

At the end will be found a table giving a summary of the observations made on the thirty cases personally examined.

(1) Distribution of the Fifth Nerve to the Skin of the Face.

(*a*) *Anæsthesia determined with camel's-hair brush.*

Method.—In investigating the distribution of true tactile anæsthesia it is, of course, clear that no method is admissible in the use of which any pressure, however slight, is made upon the surface. To prevent this error the stimulation may be made either with a fine camel-hair brush, with a hair æsthesiometer, or with a small wisp of cotton wool. In this series of investigations the camel-hair brush has been used in every case; and whenever the word anæsthesia is mentioned in this paper, it will imply, unless otherwise stated, loss of sensation to the light contact of a camel-hair brush.

Area of anæsthesia as determined by other observers.—Previous investigators, who have studied the distribution of the trigeminal nerve by means of the anæsthesia and motor changes following upon resection of the Gasserian ganglion, have devoted their attention mostly to examining the patients

at short intervals after the operation. The result of their researches is such as to indicate that the area of facial anæsthesia is fairly constant in all cases with slight individual variations, and that practically no change takes place at later periods. In fig. 1 the continuous line illustrates the average outline of loss of sensation to the hair æsthesiometer as observed by Harvey Cushing [12] ; the broken line being a very slightly simplified representation of the same. From this figure it is seen that the anterior boundary is the midline of the front of the head, of the forehead, nose, mouth and chin. The posterior margin may be described with a close approach to accuracy as consisting of three straight

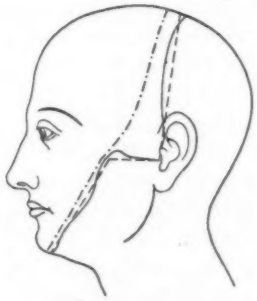


FIG. 1.

Continuous line.—Typical outline of anæsthesia, as given by Cushing.
Broken line.—The same, slightly simplified.
Dash and dot line.—Outline of analgesia.

lines (broken line in fig. 1) ; the upper line is almost vertical and extends from a point in the sagittal plane of the scalp, varying slightly about the mid-point between nasion and inion to the free margin of the tragus at the junction of its middle and lower thirds; thence the second line passes horizontally forwards to a point mid-way between the external auditory meatus and the outer canthus of the eye; here the third line begins, and runs obliquely downwards to a point on the lower border of the chin vertically beneath the angle of the mouth. The exact unsimplified boundary is shown by the continuous line in the diagram.

Its upper part has a slight anterior convexity most marked at the commencement; when it reaches the anterior attachment of the helix it follows this to the concha and then curves round the posterior aspect of the tragus, includes the external auditory meatus and membrana tympani to a greater or less extent and reappears at the junction of the middle and lower thirds of the tragus. The end of the horizontal part usually shows a sharp upward curve before it turns down into the third line, which it follows closely with slight undulations.

The posterior border of analgesia and anæsthesia to pressure-touch and heat and cold runs a much straighter course in front of the line above described.[1]

In three out of his twenty-six cases, Cushing [12] noted a uniform deviation; the posterior border of the anæsthesia including the upper half of the pinna, the antihelix and crura, part of the concha and a considerably greater area of the cheek; whilst the limits of pressure-touch anæsthesia corresponded with the normal outline of the lighter anæsthesia. He also observed one case in which the field was the same as that given by Frohse [30] as the average result of the dissection method.

Krause [50] in his monograph says that in R. Zander's researches there is an anatomical basis for the opinion that the anæsthetic area may diminish considerably, and of Case 3 of his series, Krause has given two diagrams showing the alteration in the extent and intensity of the anæsthesia between four weeks and two and a half years after the removal of the ganglion. The diminution is chiefly noticeable over the forehead and head, in front of the ear and in the neighbourhood of the jaw. But in a later article on trigeminal neuralgia [55] his diagrams show practically no shrinkage in the region of the ear.

Cushing, who has noticed some return of sensibility in the area of the ophthalmic division in two or three of his cases, attributes any change other than "an insignificant shrinkage of the border areas of the entire field" [13][2] to

[1] Fig. 1, dash and dot line. P. 219.

incomplete removal of the ganglion.[1] In his detailed description of twenty cases [13], however, he reproduces three photographs (without comment) which show an alteration of the field. The case on the tenth day had exhibited that most posterior limit of anæsthesia in which half the pinna was included; two years later the zone conformed with Cushing's normal type.

Personal Observations.—I have observed that if patients in whom the ganglion has been extirpated be examined within the months following the operation, the whole area of anæsthesia undergoes general shrinkage along the posterior margin, and that this shrinkage is more marked above than below. In some cases the shrinkage is inconspicuous or absent. The change is not a uniform recession of the posterior margin, but in some cases results in a detached area of anæsthesia remaining in the neighbourhood of the tragus. After a certain period (about six months) no further diminution occurs, and therefore in cases examined at periods longer than this after the operation, the area of anæsthesia will be found to have one of four characteristic and permanent forms: 1 and 2, the forms in which little or no reduction has occurred (figs. 2 and 5). Of these two outlines which closely resemble one another, one is very common (fig. 2) and the other rare (fig. 5); the latter will be described after the remaining forms have been dealt with; 3, the form in which pronounced reduction has taken place (fig. 4); 4, intermediate between these, the form in which the reduction has left a detached islet of anæsthesia over the tragus (fig. 3). These areas I propose to call respectively "A," "D," "C,"

[1] Pruschinin [70] records a case in which the Gasserian ganglion and its second and third divisions were removed and the sensory root ablated. Gradual return of sensation was observed. At the end of nine months tactile sensation with wool was present over the affected half of the face, and there was marked improvement in the recognition of painful stimuli. No recurrence of pain accompanied this return of sensation. Sapejko [77] also reports a case of complete trigeminal neurectomy, which, immediately after the operation, showed complete anæsthesia in the region of the fifth nerve. A year later the anæsthetic area was found to have diminished considerably.

Numerous other cases have been described (*viz.*, by Pruschinin [70], Garré [31], and Perthes [67]) in which return of sensation has been associated with return of pain and regeneration of the peripheral nerves, after a partial extirpation of the ganglion.

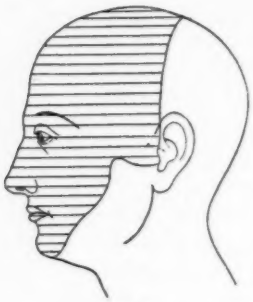


FIG. 2.
Type "A."

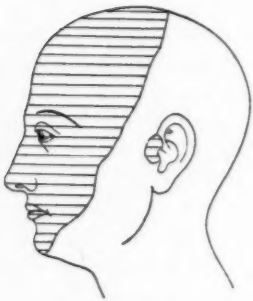


FIG. 3.
Type "B."

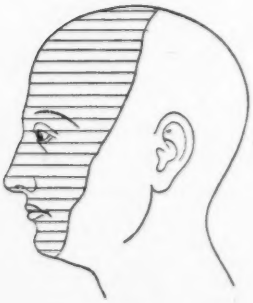


FIG. 4.
Type "C."

and "B."[1] The rest of this section will be devoted to establishing their permanence and attempting to infer their relative frequency.

If figs. 2, 3, and 4 be studied, the difference of the "A," "B," and "C" varieties are at once apparent. Type "A" (fig. 2) is practically identical with that shown in fig. 1 (continuous line), and considered by Cushing as the normal area of anæsthesia, resulting from removal of the ganglion.[2] Type "C" (fig. 4) corresponds very approximately with the area of pressure-touch anæsthesia and analgesia as

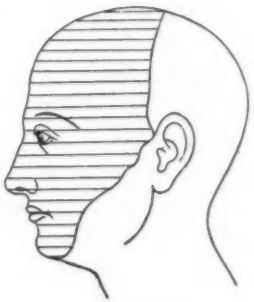


FIG. 5.
Type "D."

depicted in fig. 1 (dash and dot line). This, the type "B," also closely resembles, but shows in addition an isolated patch of anæsthesia over the tragus; this patch is of special interest in that it never shows pressure-touch anæsthesia or analgesia. In other words "A" passes into "C" by the disappearance of an area of right-angled triangular shape,

[1] Kruger (57) describes a case in which, seventy-one days after the operation, in addition to some return of sensation in the area of distribution of the first division, in the middle of the anæsthetic cheek a bridge had formed which was again sensitive.

[2] It is possible that some of the anterior branches of the small occipital nerve are divided by the posterior limb of the scalp incision, and that the anæsthesia of the skin immediately in front of this is then due to the loss of these fibres.

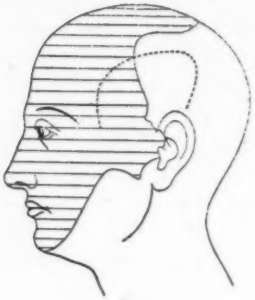


FIG. 6.
Case 23. Ninth day after operation.

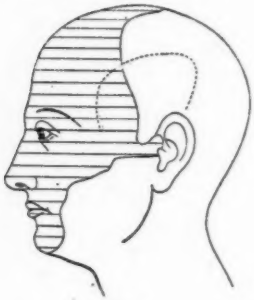


FIG. 7.
Case 23.—Forty-sixth day after operation.

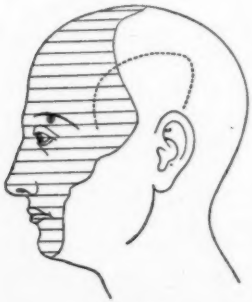


FIG. 8.
Case 23.—Sixty-seventh day after operation.

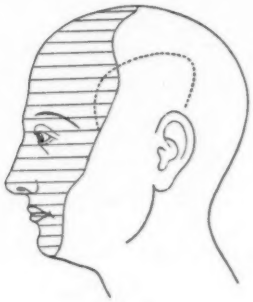


FIG. 9.
Case 23.—Hundred and ninetieth day after operation.

the right angle being at the external auditory meatus and the sides containing the angle being vertical and horizontal; "A" passes into "B" by the disappearance of this area except the part at the right angle.

Except for a modification of "A" already referred to as "D" no intermediate varieties ever occur as permanent types; they can only be observed during the transition. In "D" (fig. 5) the posterior border of the anæsthesia extends back to the helix, but curves forwards again without actually encroaching thereon; the horizontal and inferior oblique lines of the simplified outline (fig. 1) are replaced by

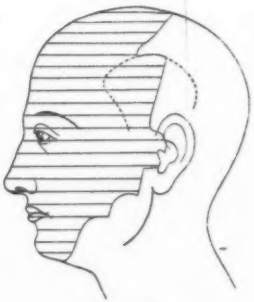


FIG. 10.
Case 27.—Twelfth day after operation.

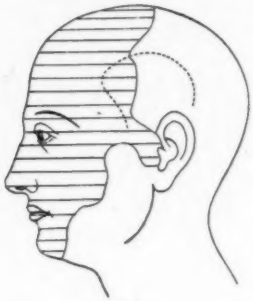


FIG. 11.
Case 27.—Seventeenth day after operation.

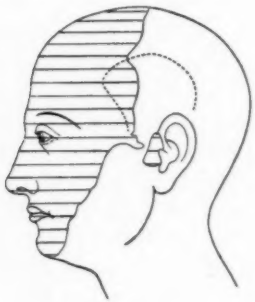


FIG. 12.
Case 27.—Twenty-second day after operation.

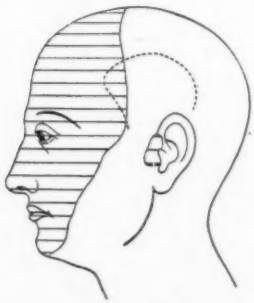


FIG. 13.
Case 27.—Fifty-fifth day after operation.

a single undulating oblique line which joins the superior vertical at the attachment of the helix.

The evidence of the permanence of these four forms of anæsthesia is as follows: Head [39 and 40] has shown that after nerve section, recovery of function, when it takes place, is frequently complete at the end of two years. It seems probable then that all changes in the anæsthetic zone after extirpation of the ganglion would be at an end by this time. Twelve[1] of the thirty cases examined in this series were seen at periods of two years or more after the operation; five[2] of these were furthermore examined more than once after the two years, and showed no alteration in the field of anæsthesia. To these may be added the three cases[3] examined more than once between one and two years subsequent to the operation, none of which showed any changes, and those three cases[4] in which the shrinkage of the field was traced from the commencement until it ceased; in the one case[5] the permanent form had been obtained by the hundred and forty-first day, in the other[6] by the fifty-fifth; the subsequent observations made three hundred and one, two hundred and sixty, and seventy-three days later respectively revealing no further alteration. In no case have I observed a continuance of the shrinkage after six months, the change when it did occur being completed generally within the first two months. In seven cases[7] this transformation was watched. The diagrams (figs. 6, 7, 8, 9) illustrate the process of shrinkage from "A" to "C" as observed on the ninth, forty-sixth, sixty-seventh, and the hundred and ninetieth days in Case 23. Again the alterations from "A" to "B" as observed on the twelfth, seventeenth, twenty-second, and fifty-fifth days in Case 27 are indicated in figs. 10, 11, 12, 13.

These four permanent forms must be taken as showing that the fifth nerve has at least four types of distribution,

[1] Cases 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 16 (see list of cases at end).
[2] Cases 6, 8, 9, 12, 13.
[3] Cases 14, 16, 17.
[4] Cases 26, 27, 30.
[5] Case 26.
[6] Case 27.
[7] Cases 21, 22, 23, 25, 26, 27, 30.

and it is therefore of great interest to attempt to estimate their relative frequency.[1]

There are nineteen cases[2] which we know to show permanent types because they were observed six months or more after the operation. These show type "A" four; "B" nine; "C" four; and "D" one. Three other cases[3] were watched through a period of change until one or other of the permanent types was reached; they may therefore be accepted with practical certainty for addition in attempting to estimate the relative frequency of types.

Of the remaining eight cases[4] two[5] are not available because the anæsthesia was not investigated with the camel-hair brush: of the six cases which are left, one[6] is type "B." There is good reason to suppose that type "B" is always permanent, and therefore this is available for the present purpose. Another[7] is of type "D," and all the evidence we have of this form is that it is permanent. This evidence, which is not very satisfactory, consists of two elements: (1) "D" has been observed at the end of twelve months; (2) "D" is certainly not an intermediate form which is passed through by "A" when undergoing transition to "B" or "C." So far then we have twenty-four cases on which the estimate of the frequency of the four types may be based. These give the frequency as follows:—

Type	"A"	"B"	"C"	"D"	Total.
Number of cases	4	12	6	2	24

These figures of course are very small, but we may take them as approximating in some way the probable proportion

[1] Before discussing the relative frequency of the permanent types of anæsthesia a word must be said of the varieties found existing as initial forms. Twelve cases were investigated for the first time at an interval after the removal of the ganglion varying between nine and twenty-four days; of these, ten showed the "A" form of anæsthesia; one anæsthesia of type "B" and one the "D" variety. These cases are: Case 2, 15 days "A"; Case 20, 16 days "D"; Case 21, 14 days "A"; Cases 22 and 23, 9 days "A"; Case 24, 9 days "B"; Case 25, 10 days "A": Case 26, 24 days "A"; Case 27, 12 days "A"; Case 28, 15 days "A"; Case 29, 12 days "A"; Case 30, 12 days "A."

[2] Cases 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 23, 25, 26, 27.

[3] Cases 21, 22, 30. Of these, Case 30 showed no change between the seventieth and the hundred and forty-third day.

[4] Cases 2, 5, 18, 19, 20, 24, 28, 29.

[5] Cases 5, 19.

[6] Case 24.

[7] Case 20.

of the areas to which the fifth nerve supplies the sensation to light touch.

It may be added that the four[1] cases which have not been included because they were only examined once, and not at a period when the anæsthesia might be considered of permanent form, were all of type "A" as was to be expected,[2] and would probably have become permanent as: one, type "A"; two, type "B"; one, type "C."

Two[3] of these cases showed a diminution of the area

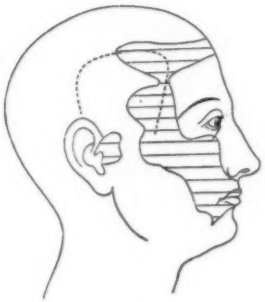


FIG. 14.
CASE 1.—Seven years after operation.

of anæsthesia, which was such as to suggest that the sensory root of the ophthalmic division of the ganglion had not been completely divided. The anæsthesia, however, which was present was sufficiently extensive to allow the cases to be classified. In one of these (Case 1), which I examined seven years after the operation, this condition had been noted on the fifth day.

Apart from these two cases, there has been no instance in this series in which any diminution of the anæsthesia along the middle line of the face has been noticed.

[1] Cases 2, 18, 28, 29. [2] See footnote [1] page 230.
[3] Case 1 (fig. 14), and Case 18.

(*b*) *Pressure-touch Anæsthesia. Analgesia. Anæsthesia to Heat and Cold.*

Method.—The limits of pressure-touch anæsthesia have been ascertained by the gentle application of the head of a large pin. The analgesia has been investigated by the use of a very sharp pin applied obliquely, so as not to penetrate the deeper layers of the cutis. In the determination of the heat and cold anæsthesia, narrow test tubes containing ice or water at different temperatures have been employed.

These forms of sensation will be considered together, as

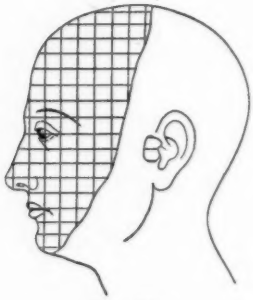


FIG. 15.

Type "X."—Vertical shading showing the relation to Type "B."—Horizontal shading.

in almost all cases they have been found to correspond; but those cases which show any divergence will be dealt with separately. Whenever analgesia only is mentioned, it will be understood that the distribution of this form of loss of sensation corresponded to that of the thermo-anæsthesia and loss of sensibility to pressure, unless otherwise stated.

Analgesia will be considered first in relation to anæsthesia, in those twenty-four cases[1] which have settled down to their permanent forms. The same proofs which were used to establish a permanency of type after a certain period for the anæsthesia, apply equally well to the analgesia, and so need not be repeated.

[1] Cases 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 30.

In discussing the anæsthesia, it was shown that there were four different forms which had to be considered as permanent. Associated with these there are three forms of analgesia which must now be discussed.

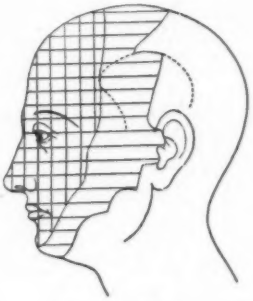


FIG. 16.

Case 27.—Twelfth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

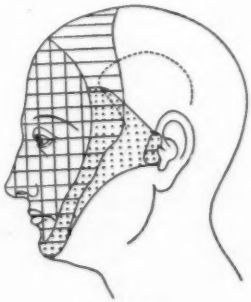


FIG. 17.

Case 27.—Three hundred and fifteenth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Dotted area.—Temperatures from 0° C. to 12° C. described as warm; temperature from 18° C. to 50° C. described as cold; temperatures between 12° C. and 18° C. not recognised as hot or cold; temperatures above 50° C. called hot.

In all these cases exhibiting either the "B" or "C" form of anæsthesia,[1] a constant distribution of the analgesic field

[1] Cases 1, 3, 8, 9, 10, 11, 12, 14, 16, 17, 21, 22 23, 24, 25, 26, 27, 30.

has been found. This area corresponds with that of the anæsthesia of type "C," so also with that of "B," except that the isolated area over the tragus is not analgesic (fig. 15), and it constitutes the most common permanent analgesic area. It will be referred to as type "X," and is found in fifteen cases.[1]

There are three exceptions to this. In Case 27 the analgesic area is considerably less than the anæsthetic; this marked diminution of the field was noted even on the twelfth day after the operation (fig. 16), and was still more marked on the three hundred and fifteenth (fig. 17). Case 9

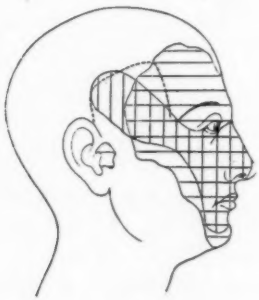


FIG. 18.

Case 3.—Five years after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

shows a very slightly narrower area of the pressure-touch and analgesic field opposite the lobule and tragus, and over part of the area of the operation flap, the heat and cold anæsthesia are replaced by heat and cold paræsthesiæ (fig. 25). Finally, Case 3 exhibits a relationship of the analgesic and anæsthetic areas totally different from all others (fig. 18). It is necessary to state, however, that the man was extremely unsatisfactory to examine, and that the figure here given embodies the most constant answers which could be obtained.

Those patients who exhibit the "A" type of anæsthesia

[1] Cases 1, 8, 10, 11, 12, 14, 16, 17, 21, 22, 23, 24, 25, 26, 30.

show that form of analgesia which will be called "Y" (fig. 19).[1] Its limits cannot be defined with great accuracy, as the posterior margin varies slightly with each individual

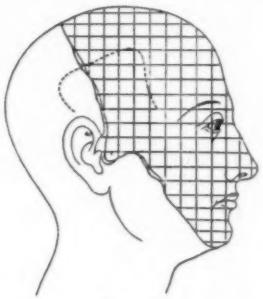


FIG. 19.

Case 13.—Twenty-one months after operation.
Type "Y."—Vertical shading showing the relation to
Type "A."—Horizontal shading.

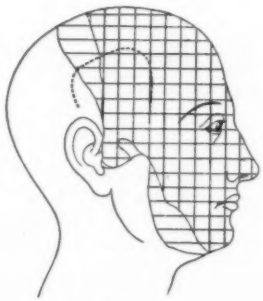


FIG. 20.

Case 6.—Four years, four and a half months after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

case; but it may be said that the analgesia does not extend quite so far back as the anæsthesia, especially with regard to the tragus. Fig. 20[2] illustrates the most marked separation observed of the posterior limits of these fields at the upper

[1] Case 13. [2] Case 6.

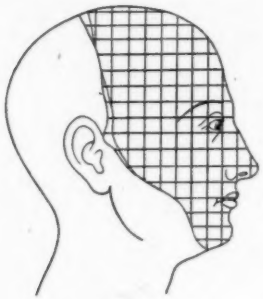


FIG. 21.

Type "Z."—Vertical shading showing the relation to Type "D."—Horizontal shading.

and lower borders, and their closest approximation at the tragus.

Closely allied to "Y" is type "Z" (fig. 21), which depicts the relationship of the analgesia to the anæsthesia in the two cases,[1] in which the anæsthesia was of the "D" form.

In those cases[2] of "A" seen whilst the changes to camel-hair anæsthesia were in progress, the posterior

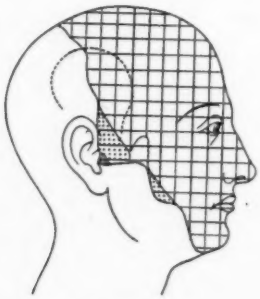


FIG. 22.

Case 30.—Twelfth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Dotted area.—All temperatures from 50° C. to 0° C. called warm.

[1] Cases 15 and 20. [2] Cases 21, 22, 23, 25, 26, 27, 28, 29, 30.

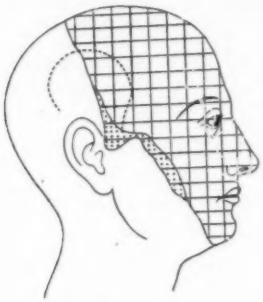


FIG. 23.

Case 30.—Thirty-fourth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Dotted area.—Temperatures from 50° C. to 0° C. variously recognised. At times differences of 10° C. accurately recognised; at other times temperature of 26° C. described as hotter than temperature of 45° C.

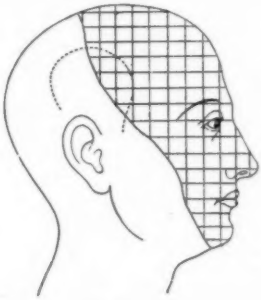


FIG. 24.

Case 30.—Seventieth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
There was no paræsthesia to heat or cold.

margin of the analgesic zone is generally found to be at a variable slight distance in front of that of the anæsthetic area; and as "A" shrinks to "B" or "C," the analgesia recedes in front of it, but more slowly, until the two fields correspond.

In figs. 22, 23, and 24, are shown the relative conditions and changes which took place in the several sensations in

Case 30 between the twelfth and seventieth days after the operation.

Blunting of the sensation of heat and cold.—In these three figures just referred to, it will be seen that, in addition to the areas of absolute anæsthesia and analgesia, there is also a zone posterior to the analgesic, but contained within the anæsthetic field, in which there is a perversion of the heat and cold sensations. As the areas of loss of the various sensations reach their final form, this patch of impaired reaction to thermal stimuli diminishes and finally disappears.

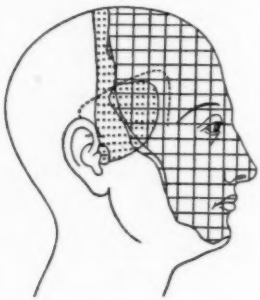


FIG. 25.

Case 9.—Three years and seven months after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Dotted area.—All temperatures from 0° C. upwards called warm.

In some of the patients, however, this area of thermal perversion has been found present even after two or more years. In Case 9 (fig. 25) the loss of heat and cold sensations is complete over the greater part of the analgesic area, but over a portion of the operation flap, and a strip posterior to this (dotted) all temperatures down to ice are called warm.

Two other patients likewise show an area of perversion of the thermal sense. In Case 17 there is a band one and a half centimetres wide running in front of the posterior border of the analgesic and pressure-touch area, and slightly overlapping the sensory field below, over which all degrees of cold down to ice are described as warm. More interesting still,

however, is Case 16 (fig. 26). This patient, when seen two years after operation, exhibited the "B" type of anæsthesia and the "X" type of analgesia; yet behind this was an area occupying almost exactly the area between the "A" and "C" forms of anæsthesia, on which all temperatures above 40° C. were considered warm, those below 5° C. cold, whilst intermediate temperatures were not recognised. Whilst another patient, when examined one year, seven and a half months after the operation, was found to have anæsthesia of the "B" variety, analgesia of the "X" variety, and complete loss of sensation for all temperatures over an area corresponding to that of the "A" type of anæsthesia.

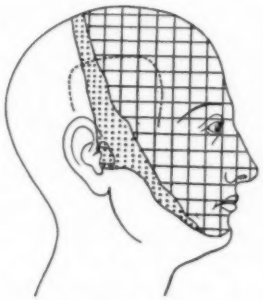


FIG. 26.

Case 16.—Two years after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Dotted area.—Temperatures between 5° C. and 40° C. not recognised.

The evidence afforded by these cases is too small to permit of discussion of this condition, but would nevertheless seem to show that they form still further intervening types between "A" and "C."

The greater part of the observations upon which this paper is founded were made before Head's [39 and 40] recent publications on the peripheral nervous system. Nine of the cases have been investigated, however, in the light of these researches. It was obvious from the first, however, that two groups of sensory loss were to be found within the

field of disturbance of sensation, and not necessarily occupying areas of the same size. These two groups which have been referred to as anæsthesia and analgesia consist respectively of loss of sensibility to light touches and of loss of sensibility to pressure, pain, heat and cold. They show, therefore, a general resemblance to the grouping of sensations found in the limbs by Head (loss of epicritic and loss of protopathic sensations respectively), but they present certain marked differences. For example, in the intermediate areas between the limits of total anæsthesia and that of loss of sensibility to light touches only, there were none of the features described by Head as being characteristic of regions which have protopathic sensibility only, there was no disturbance of the thermal sense, and there was no exaggerated discomfort resulting from painful stimuli.[1]

With regard to the relation of these two sensory losses, three main groups can be recognised.

(1) Cases in which anæsthesia and analgesia coincided, *i.e.*, there was a single area of total loss of sensibility, with a definite margin at which there was an abrupt transition to normal sensibility.

(2) Cases in which loss of sensibility to light touches was more extensive than the loss to pain, pressure, heat and cold; each of these two areas had a definite margin, and in the intermediate region the only abnormality was a failure to recognise light touches (types "A," "B," and "D.")

(3) Certain cases in which, to the disturbances found in the second class just mentioned, were added partial interferences with the thermal sense in areas which for the most part lay outside the distribution of any other sensory loss,

[1] Hyperæsthesia and hypalgesia have been noticed by some observers, *e.g.*, Friedrick [29], who gives two diagrams. The first (forty-seven days after operation) shows some hyperæsthesia and hypalgesia over the chin and a narrow strip in front of the upper area of distribution of the third division of the fifth. In the second figure (102 days after operation) it is seen that the area supplied by the first division is no longer anæsthetic and analgesic, except for a small area on the forehead; also that there is some retraction of the posterior border of anæsthesia on the cheek, whilst there is extension of this area over the chin. These areas of diminished anæsthesia and analgesia are now, however, hyperæsthetic and hypalgesic. Garré [31], also mentions a case in which there was hyperæsthesia in front of the ear, and over part of the upper jaw and gum on the hundred and eighth day.

and were, therefore, not intermediate areas in the sense used by Head. These thermal sense losses were very irregular in kind, and nothing was found corresponding with the localised loss of discrimination of temperatures between 22° C. and 40° C., which were described by Head as characteristic of areas which have protopathic sensibility only. In one case, however (fig. 26), there was inability to discriminate amongst temperatures between 5° C. and 40° C.; the area in which this loss was found lay for the most part outside the region in which sensibility to light touches was absent. For diagrams illustrating some of the disturbances in the thermal sense see figs. 17, 22, 23, 25, 26.

In no case was it established satisfactorily that there was any extension of the analgesic area beyond the anæsthetic.

Attention may here be called once more to the fact that on the mucous membranes, anæsthesia and analgesia invariably and precisely coincided.

Dana [15], in a patient in whom the third division of the fifth was cut intracranially, found that there was a single area of total loss of sensibility on the face and in the mouth.

It may be added that deep sensation was invariably absent in regions where there was total loss of sensibility of the skin; this would seem to be satisfactory evidence that sensory fibres from the muscles of the face travel in the fifth nerve.

(*c*) *Paræsthesiæ.*

All the patients experience some kind of abnormal sensation on the side of the face, eye or mouth, after the operation, and they make use of various terms to express their sensations. The most common complaint is that of a "burning" sensation, and this was most marked in Case 23. The face was not universally affected, but the burning was localised to a series of patches, as shown in the accompanying diagram,[1] where it will be seen that these areas are not confined entirely to the area devoid of sensation, although they are included within the field of the original anæsthesia. There is also

[1] Fig. 27.

indicated in the diagram that part at which a "boring" pain was experienced. The burning was, however, most marked in the mouth, along the left side of the tongue, throat, and palate. In another case[1] there were some parts of the face which felt burning, and at the same time others which felt icy cold.

Some patients complain of the sensation of pins and needles, of tickling and of stinging. Most of them complain

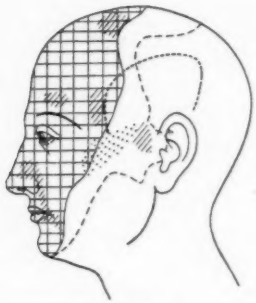


FIG. 27.

Case 23.—Hundred and ninetieth day after operation.
Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.
Oblique shading indicates the seat of "burning sensation."
Dotted area indicates the seat of "boring pain."
Broken line marks posterior limit of the original area of anæsthesia.
This patient was extremely neurasthenic.

of the affected side of the face as feeling numb, drawn or shrinking, and of the mouth as feeling swollen or woolly. Others, again, feel that the face is flushed, or that the lateral angle of the eye and mouth is twitching, even when nothing of this kind is apparent on examination. One patient writing to me described his sensations as follows:[2] "The most general is that which feels as though a fly were walking about the face; this, at times, seems to be multiplied to a score of flies, running in all directions, specially down side of nose. Another has the feeling of violent itching. Another is a

[1] Case 15.
[2] Case 13.—This description was written two years after the operation.

tremulous sensation specially round right eye, and in upper and lower lids. Another time a most acute stinging sensation, which occurs in left corner of right eye along the right side of tongue, and on the right side of both lips, when this occurs the inside of the mouth swells. Another is a jarring sensation as though I had bitten something, and my teeth had come together with a snap. I also get a general shock, which involves the whole of the side affected."

Whilst another patient[1] wrote that he had a "buzzing sensation in the left ear, which changes to a sharp pain across the top of the head, and a creepy-crawly sensation in the right cheek. I do not get the burning tic-douloureux like I used to before the operation . . . . . at times I get a burning sensation in the right eye, and a film of water spreads across it."

Both these patients were extremely neurasthenic.

Neurasthenia is commonly found in these patients after the operation, and this makes it difficult to estimate how much these sensations of discomfort must be attributed directly to loss of function of the fifth nerve. There is no reason to suppose that in these cases neurasthenia is more frequent than in other cases of equal severity, or that it has anything to do with the nature of the operation.

(2) Distribution to the External Auditory Meatus and Membrana Tympani.

Method.—In all these cases, the examination of the drum has been carried out by means of fine horse-hair. A speculum is inserted into the external auditory meatus, and after it has been retained there for about a minute the patient is able to dissociate the sensory stimulus set up by the speculum from stimuli induced by the horse-hair on the drum or the deeper part of the meatus. When a sensitive drum is touched with horse-hair, the patient usually rapidly withdraws the head and complains of two distinct sensations: one auditory, a loud tap being heard, and the other a feeling

[1] Case 10.—These symptoms were detailed three years after the operation.

of a very painful pin prick; whilst, if the horse-hair is drawn along the surface of the membrane, an irritating sensation is set up. In these cases, in which the membrane is insensitive, only the auditory stimulus is perceived. The outer part of the meatus is examined, after the withdrawal of the speculum, either by means of the horse-hair or a fine camel-hair pencil. Occasionally the hairs springing from the posterior surface of the tragus have to be cut away.

Krause [50] states that the external auditory meatus, especially the anterior wall at its commencement, is anæsthetic, but believes with Frohse [30] that this canal is supplied to a variable extent by the auricular branch of the vagus, and that the drum always derives its sensibility from that nerve. Cushing [12 and 13], who alone has made a careful clinical study of the anæsthetic boundaries of these parts, finds that in most cases the upper and anterior walls of the canal are anæsthetic, and the drum also to a greater or less extent.

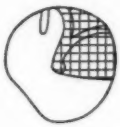
The results of my examination of the auditory canal and tympanic membrane in twenty-five[1] cases, show that no uniformity in the anæsthesia exists, and that not even is there any correlation possible of the range of involvement of these parts with the different types of facial anæsthesia. This is well illustrated by the fact that in the four cases[2] where no anæsthesia of the meatus was present, and in all[3] those in which there was no anæsthesia of the drum, each of the four types of facial anæsthesia was represented.

Anæsthesia, partial or complete, was found to be much commoner of the meatus than of the drum, as can be seen by referring to the appended tables; whilst in every case, where there was any loss of sensation in the auditory canal,[4] the anterior wall was affected; and except in Case 12, in which the outer opening of the meatus alone remained sensitive, those walls which were anæsthetic were involved along their whole length.

[1] Cases 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30.
[2] Cases 16, 20, 22, 28.
[3] Cases 3, 4, 6, 17, 20, 22, 24, 25, 26, 28.
[4] Cases 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 21, 23, 24, 25, 26, 27, 30.

Five cases[1] showed complete anæsthesia of the drum and of the whole of the external auditory meatus, including the posterior aspect of the tragus; whilst two others,[2] in which the tympanic membrane was totally devoid of sensation, had almost complete anæsthesia of the canal. In three cases[3] the auditory canal and membrane showed no loss of sensa-

FIG. 28.



Case 10.

FIG. 29.

Case 21.

FIG. 30.

Case 13.

FIG. 31.

Case 15.

FIG. 32.

Case 23.

Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

tion. Seven[4] of the patients had no affection of the tympanic membrane, but had anæsthesia of the meatus in varying degrees, from complete insensibility in Case 4 to affection of the anterior wall only in Case 3.

The remaining eight cases[5] exhibited great irregularities

[1] Cases 1, 7, 8, 14, 27.
[2] Cases 9, 30.
[3] Cases 20, 22, 28.
[4] Cases 3, 4, 6, 17, 24, 25, 26.
[5] Cases 10, 11, 12, 13, 15, 16, 21, 23.

in the distribution of the sensitive and insensitive areas; three only need special mention. Case 16 had anæsthesia of the superior and anterior parts of the tympanic membrane, but the whole of the external auditory canal was sensitive. Case 23[1] showed anæsthesia of the whole drum except the anterior part, whilst in the auditory canal the posterior wall was the only one which had not lost its sensation. Case 12 is of special interest as the tympanic membrane had been destroyed by otitis media many years before. The greater part of the external auditory meatus was anæsthetic, but beyond the site of the membrane horsehair stimulation produced the feeling of light touch, and no auditory sensations were obtained. Figures 28 to 32 illustrate the anæsthesia on the membrane of Cases 10, 13, 15, 21, 23.

In none of the cases even when seen at varying periods up to one year was there any change.

It has only been possible to investigate analgesia on the walls of the meatus, and here it was found to correspond exactly with the anæsthesia.

Anæsthesia of the External Auditory Meatus according to the Number of Walls Involved.

4 walls.		3 walls.		2 walls.		1 wall.		No anæsthesia.		Total.
10	...	4	...	5	...	2	...	4	...	25

Relative Affection of the various Walls in the 21 Cases which showed Anæsthesia.

Anterior.		Posterior.		Superior.		Inferior.
21	...	12	...	16	...	15

Anæsthesia of Tympanic Membrane.

Complete.		Partial.		None.		Total.
7	...	7	...	10	...	24

(3) Distribution to the Mucous Membrane.

After the removal of the Gasserian ganglion the mucous membrane of the cheek, the lips, of the gums of both upper and lower jaws, the roof and floor of the mouth, the anterior

[1] Fig. 32.

part of the tongue, and the nose on the same side, as far as the middle line, invariably become anæsthetic to all forms of sensation. The limit of the insensitive area on the tongue posteriorly and the line of its reflection on to the soft palate, the involvement of the anterior and posterior palatine arches of the nasal portion of the pharynx are, however, subject to considerable variations.

Krause [50] states that the palato-glossal arch and the palatal fold are usually anæsthetic. Cushing [12 and 13] traces the limit of sensory loss along the middle of the tongue almost as far back as the foramen cæcum, then outwards along the circumvallate papillæ to the root of the tongue laterally where individual variations exist, though in the greater number of cases the line follows the palato-glossal fold to the upper part of the anterior pillar of the fauces, and continues along this to the uvula; thence curving round the free margin of the soft palate traverses its roof to reach the lateral pharyngeal wall and turn upwards bisecting the Eustachian orifice to reach the midline of the pharynx and so return by the posterior edge of the nasal septum to the soft palate. The posterior pillar of the fauces, the lower portion of the anterior pillar and the tonsil remained sensitive in all the cases.

I have found considerably greater variations in the anæsthesia of the soft palate in the twenty-six cases I examined[1] from this point of view. These variations may be divided into three groups to each of which a sub-group is added.

In group 1 (fig. 33) the anæsthesia extending down the midline of the hard and soft palate, reaching the tip of the uvula, sweeps outwards along the margin of the uvula and of the anterior palatine arch to the lower end of the latter and then to the floor of the mouth. In these cases, therefore, the posterior palatine arch and the tonsil retain their normal sensibility. The difference in the sub-group is that, opposite the tonsil, the margin of the anæsthesia is

[1] These examinations were made at periods varying from nine days to seven years after the operation.

slightly anterior to the edge of the palatine fold. There are seven examples[1] of group 1, and two[2] of its sub-group.

Group 2 (fig. 34) also contains seven cases.[3] In it the uvula is anæsthetic, but the whole of the free margin of the palate, of the anterior pillar, along a strip half a centimetre wide, retains its sensibility, together with the tonsil and posterior arch.[4] In the sub-group, of which there are two examples,[5] the uvula also is sensitive.

Group 3 (fig. 35), which has five examples,[6] shows the greatest range of anæsthesia. The whole of the soft palate, the uvula, the anterior and posterior pillars of the fauces, and the tonsil have lost their sensibility. In the sub-group, two patients[7] have retained sensibility along the extreme edge of the posterior arch and of the tonsil, together with the lower third of the latter; whilst in one case[8] the border of the anæsthesia running along the free margin of the palate suddenly turns outwards across the upper third of the tonsil, and then continues down the edge of the anterior pillar.

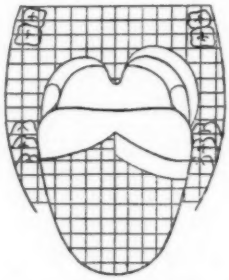
In only one patient[9] did the anæsthesia fail to reach the middle line. This man had had a second operation for recurrent pain, when some strands of connective tissue containing nerve filaments, which were found crossing the cavum meckelii, were cut away. When examined two and a quarter years later, he was suffering from neurasthenia, and complained of various abnormal sensations, including one of pain[10] on the same side of the face. The anæsthesia on his face was of the "C" type, and was complete up to the middle line. The anæsthetic area in his mouth is shown in fig. 36.

In those cases which fall under groups 1 and 2, in which the free margin of the palate remains sensitive, a palatal reflex can be obtained by stimulating this edge; in the other cases no reflex is obtained.

[1] Cases 6, 12, 14, 16, 21, 25, 28.
[2] Cases 3, 7.
[3] Cases 15, 18, 20, 23, 24, 26, 27.
[4] Krause notes a similar condition in the case of one of his patients, Frau, Prof. R.
[5] Cases 8, 19.
[6] Cases 1, 4, 11, 29, 30.
[7] Cases 17, 22.
[8] Case 13.
[9] Case 10.
[10] See p. 22.

The anæsthetic area of the tongue is more uniform. In eighteen cases[1] the lateral half as far back as the circumvallate papillæ was affected (fig. 33); whilst in six[2] the

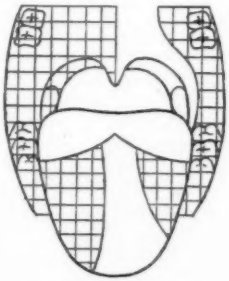
FIG. 33. FIG. 34.



Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

posterior limit ceased one centimetre in front of this (fig. 34). Only three were exceptional. In Case 12 there was a strip half a centimetre wide along the median line of the dorsum which retained sensibility (fig. 35). In Case 15[3] no anæsthesia

FIG. 35. FIG. 36.



Horizontal shading denotes anæsthesia.
Vertical shading denotes analgesia.

[1] Cases 1, 3, 4, 7, 8, 11, 16, 17, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30.
[2] Cases 6, 13, 14, 18, 24, 25. [3] Examined one year after the operation.

of the dorsum could be detected. Krause [50] mentions that in one of his patients, when seen two years after the operation, light contact was distinctly felt on the lip and upper surface of the tongue. Case 10 (fig. 36) has already been mentioned.

As in the anæsthesia of the auditory meatus and drum, so in the anæsthesia of the buccal mucous membrane, no change in the original areas has been found to take place.

(4) Distribution to the Deep Structures.

(*a*) *To the Dura Mater.*

The fifth nerve is mainly responsible for the innervation of the dura mater on the same side. Certainly no pain is experienced by the patients when the drainage plug is withdrawn from the deeper parts of the wound on the day after the operation. Cushing [12] had a case in which the ganglion was removed, together with the greater part of a basal neoplasm; the wound was left open for the application of the X-rays, and the dura of the middle fossa and temporal regions, which was exposed, was found to be completely insensible to any kind of stimulation.

Another interesting result of this anæsthesia of the dura is that headaches never occur on the side of the operation, but are confined entirely to the normal half of the cranium. Only one patient,[1] who had severe neurasthenia, complained of bilateral headaches after extirpation of the ganglion.

(*b*) *To the Subcutaneous Parts of the Face.*

Whilst sensation to the camel-hair brush and pressure touch is absent in the areas already indicated, deep pressure is occasionally appreciated in them. If the lip is pinched or compressed against the false teeth, the patient is quite oblivious of the action, so, too, if the ala nasi on the side of the operation is seized by a pair of forceps without causing any movement of the opposite nostril. Pressure on the eyeball through the closed eyelids gives rise to no sensation

[1] Case 23.

either of touch, pain, or light. When, however, the finger strongly compresses the soft tissues on to the underlying bone, the patients usually state that they can feel a slight touch, yet, if asked to indicate the spot, the localisation is extremely imperfect, the forehead or chin being pointed to instead of the cheek, or *vice versa*.

In four cases various operations had to be performed, and these admitted of an investigation of the sensibility of some of the deeper parts. In Case 26 five teeth were extracted from the upper and lower jaws on the side of the operation; no anæsthetic was administered and no pain was felt. Case 25 had her eye excised on account of neuropathic keratitis, which, owing to the patient's neglect, had led to panopthalmitis; no pain was experienced during any part of the operation, there was no alteration in the pulse when the optic nerve was cut, nor was any sensation of light observed, although the patient had been told before the operation to note carefully any sensation she might experience.

Another patient,[1] who came up to see me at my request, one year after the left ganglion had been removed, stated that he had a hole in the left side of his mouth. A large ulcerating cavity was found on the inner side of the alveolar margin leading into the antrum, the skin also on the outer side of the cheek was discoloured and breaking down. He was found to have a carcinomatous growth, primary of the alveolar margin, and invading secondarily the maxillary antrum. The tumour was inoperable, but owing to the foul state of the patient's mouth he was taken into the hospital. An incision was made over the zygomatic arch, which was affected, part of this bone was removed and the whole growth curetted; the greater part of the external and inferior walls of the superior maxilla had been destroyed, but neither during the operation, nor previously to it, had the patient suffered any pain.

In the fourth case,[2] the left Gasserian ganglion had been extirpated, together with an endothelioma which was growing from it. Three months later, owing to an extensive recurrence, a horizontal incision was made at the level of

[1] Case 15. [2] Case 18.

the lower border of the external auditory meatus. At a depth of three-quarters of an inch beneath the surface, a cavity was found which extended up to the zygoma, and from which a sequestrum was removed; no pain was felt during this operation.

Lynn Thomas [87] removed an epithelioma from the lip of one of his patients without causing any pain.

(*c*) *Muscle Sense.*

See section 6A.

(5) Distribution to the Organs of Special Sense.

(*a*) *Taste.*

Method.—The examination of the sense of taste is difficult, partly because the patient very rapidly becomes tired, and partly because even in a normal person some practice is necessary for the accurate recognition of the substance applied.

The procedure adopted in all the cases I have examined has been as follows: The tongue having been protruded, the surface is carefully dried, and the end of the organ is then held by the examiner to assist the patient in keeping it outside the mouth. The substance to be recognised is then applied by means of a glass rod. As soon as the patient appreciates a taste, he holds up his hand and the tongue is then released. Care must be taken that the sensation experienced, whilst the tongue is protruded, is expressed. Between individual applications the mouth is thoroughly rinsed out with water. The first few series of observations are not recorded, but they enable the patient to understand his part of the performance and afford him the necessary preliminary practice. Both sides of the tongue are always tested, and the examination, when possible, is not conducted for long at a time.

The substances used have in all cases been :—

(1) Saturated solution of salt.
(2) Sugar in the form of syrup.
(3) A weak solution of quinine hydrochloride.
(4) A weak solution of acetic acid.

The errors that may arise are :—

(1) The spreading of the solution to the opposite half of the tongue.

(2) The patient may experience a sensation of taste, without recognising the substance whilst the tongue is protruded, but appreciating its nature on withdrawing the tongue and opposing the mucous membranes of the tongue and palate, may name the taste in answering.

Much has been written about the course of the taste fibres, and the results published of the investigations of series of cases in which the Gasserian ganglion has been removed ; of isolated examples of destruction of single branches of the fifth cranial nerve or of the entire nerve ; of paralysis of the seventh and ninth cranial nerves, and also of numerous experiments on animals. But our knowledge of the course of the gustatory fibres has been very little increased since three years ago, when Harvey Cushing [14] published the results of his post-operative investigations of thirteen cases [1] of trigeminal neuralgia, and gave at the same time a comprehensive survey of the general literature.

Except for these two papers of Cushing and the monograph of Krause [50], there have been no articles dealing at length with the question of taste in conjunction with any large series of cases of trigeminal neurectomy, and the previous authors have had to be content with the repetition of those cases in which ageusia was observed to follow fracture of the base of the skull, syphilitic lesions of the cranial nerves, and, in a few isolated cases, of tumours involving one or more branches of the trigeminus, or of direct injury to this nerve, together with the evidence obtained from a certain amount of experimental work on animals.

Had not so many definite assertions been made and considered proved by the findings in these cases, it would have seemed unnecessary to lay stress on the slight value of statements definitely attributing the loss of taste to the destruc-

[1] In the *Journal of the American Medical Association*, April 8, 1905, Cushing, in his paper, "The Surgical Aspects of Major Neuralgia of the Trigeminal Nerve," adds his findings in another seven cases.

tion of a certain nerve, when the patient was either suffering from syphilitic gummata or from fracture of the basis cranii, in either of which lesions it is impossible clinically to be absolutely certain that one nerve only is completely destroyed.

In the controversy that exists concerning the course of the taste fibres, practically[1] all are agreed that the glossopharyngeal supplies the posterior third of the tongue, and that the chorda tympani may be the initial channel of conveyance for the fibres from the anterior two thirds. It is in reference to the connection between the chorda tympani and the brain that the great disagreement arises, and there are two parties to the argument; the one regarding the trigeminus as an essential in the course of these impulses, the other upholding the facial or the glossopharyngeal route.

Among those in favour of the fifth nerve hypothesis may be mentioned Erb [22, 23, 24], who gives three cases in which loss of taste accompanied lesions either syphilitic or traumatic of the trigeminus; Salomonsohn [76], who found ageusia in a patient with a malignant metastatic deposit involving the superior maxillary branch of the fifth; Scheier [79], in whose article the views of many previous authorities are carefully detailed, and who quotes two cases of injury associated with loss of taste; he is uncertain, however, by which branch of the trigeminus the taste fibres reach the Gasserian ganglion. Schmidt [81] and Kron [56], their views also mainly based on cases in which the lesion was traumatic or syphilitic, are of the same opinion. Ziehl [100] considers that the fibres on leaving the geniculate ganglion of the facial, pass either by the small superficial petrosal, or by the tympanic plexus (*R. communicans N. facialis*) perhaps by both to the otic ganglion, and so enter the Gasserian ganglion by the inferior maxillary division; he also suggests that they may pass by the superior maxillary branch of the trigeminus, the route varying in different people. Potts and Spiller [69] mention a case of solitary tubercle of the pons, in which ageusia of one side of the

[1] Wolfe [99] holds that the chorda tympani supplies only the anterior third of the tongue, but Schulte [82] considers that in Wolfe's case the chorda tympani was only partially divided.

tongue was present; at the autopsy, marked degeneration of the trigeminus and facial of the same side was found, whilst the abducens nucleus and "probably" the facial nucleus, were unimpaired; from this the authors conclude that the taste fibres run in the trigeminus.

In this country Gowers [32, 33, 34, 35] is the great advocate of the fifth nerve hypothesis; and in addition to the two cases of disease of the trigeminus associated with ageusia, he gives the results of four cases operated on by Sir Victor Horsley and one by Mr. Ballance, in all of which taste was completely absent [35]. In his "Diseases of the Nervous System," Gowers further says that in all cases which he has seen where disease of the fifth nerve existed, there was loss of taste both on the front and back of the tongue on that side, and on the arches of the palate; the course of the taste fibres to the posterior part of the tongue he traces through the communication of the sphenopalatine and otic ganglion with the glossopharyngeal, by a branch from the great superficial petrosal, and the small petrosal nerves to the tympanic nerve of Jacobson.

Much stress has been laid on the case published by Fergusson [27], in which there was loss of taste for two years prior to the patient's death. At the autopsy, an exostosis was found in the scaphoid fossa, which, pressing on the posterior opening of the Vidian canal, had destroyed the Vidian nerve. Fergusson says that degeneration could be traced along the Vidian and its two branches, through the geniculate ganglion up to the point at which the chorda tympani was given off, thence could be followed through this nerve and finally along the lingual branch of the third division of the fifth. But as Cushing [14][1] says: "No mention is made of any histological demonstration of evidence of degeneration, nor are the methods of studying what must have been a most difficult and arduous problem even suggested. In view, therefore, of the isolarity of this case, and of morphological studies which show that the superficial petrosal is an outshoot of the *G. geniculatum*, the observa-

[1] P. 72, foot note 13.

tion hardly deserves the keystone position which it has been given."

Stewart [83] and Turner [93] are both of the opinion that the fifth nerve conducts the gustatory fibres. J. Hutchinson, jun. [45], mentions a case in which after excision of the Gasserian ganglion and its second and third divisions, taste was lost. Blüher [2] found this also in a case where Schlange had divided the inferior maxillary branch intracranially.

Finally, the support afforded by certain experiments must be given. Schiff [80] found that section of the central root of the Gasserian ganglion abolished taste, but that this did not occur if the first and third divisions of the trigeminus were alone cut, nor if intracranial section of the facial was performed: section of the second division of the fifth, however, just in front of the ganglion, and lesions implicating the facial in the petrous bone were associated with ageusia: further, that section of the lingual above its junction with the chorda tympani was accompanied by complete loss of tactile and painful sensations and partial loss of taste. Schiff concluded, therefore, that the fibres travelled from the Gasserian ganglion down the superior maxillary branch to Meckel's ganglion, thence by the great superficial petrosal to the geniculate ganglion, from which two sets of taste fibres passed off; some travelling by the chorda tympani to the lingual, the others reaching that nerve through the small superficial petrosal and the otic ganglion. Vulpian [95], working with M. Prevost, of Geneva, found no alteration in the great superficial petrosal, nor in the chorda tympani after excision of the sphenopalatine ganglion; section of the intracranial part of the facial was only occasionally followed by slight degeneration in the chorda tympani, but this nerve was always degenerated after section of the fifth branches (in rabbits).

The course of the taste fibres, according to these authorities, is then through the lingual, the chorda tympani and facial to the geniculate ganglion, thence either by the great superficial petrosal and the sphenopalatine ganglion to the second division of the trigeminus (Erb, Gowers, Schiff), or

through the small superficial petrosal and the otic ganglion to the third division of the fifth (Ziehl, Schmidt).

In direct opposition to this are Cushing and Krause, whose views, based on a series of cases of trigeminal neurectomy, will be considered presently. Morat [65] discussing "Gustatory Sense," says :—

"The opinion which has prevailed concerning the function of the small root of the facial or nerve of Wrisberg is, that it represents an aberrant origin of the glossopharyngeal nerve, which is destined for the tip of the tongue by the path of the chorda tympani . . . . Intracranial paralysis of the facial and section of the chorda tympani are accompanied with *a marked diminution of taste at the tip of the tongue, and of the pillars of the soft palate.*"[1]

Dixon [19 and 20] has shown that the chorda tympani in early life is unassociated with the lingual, and probably carries impulses to the geniculate ganglion of the facial; similarly the great superficial petrosal is an outgrowth of the cells of this ganglion, and Jacobson's nerve which is derived from the ganglion of the glossopharyngeal, conducts impulses to it. "Can we resist," then, he says, "the conclusion that the taste impulses reach the brain by seven and nine?" Strong [85] states that the seventh nerve is undoubtedly the nerve of taste in the lower vertebrates. Haycraft [38] bases his objection to the part played by the fifth on developmental and morphological grounds, also on the small percentage of cases in which taste is lost after resection of the Gasserian ganglion and its second and third branches. Lussana [61] favours the seventh and the pars intermedia as the path for gustatory impulses; whilst Hermann [41] believes it to be in the glossopharyngeal. According to Landois [58], who is supported by Carl [6], the taste fibres pass from the glossopharyngeal to the chorda tympani by various routes.

(1) Through the intermediary portion of Wrisberg.

(2) By a small filament (ramus communicans) from the digastric branch of the facial, which joins the glossopharyngeal near the stylomastoid foramen.

[1] P. 176.

(3) In the tympanum by a filament uniting the small superficial petrosal of the facial, and the tympanic branch of the glossopharyngeal.

(4) By small filaments connecting the trunk of the facial in the Fallopian canal with the petrous ganglion of the glossopharyngeal.

Schulte [82] found that section of the seventh or fifth at the base of the skull produced no loss of taste, and therefore concluded that the fibres ran in the ninth. In addition, there is the evidence afforded by the reports of observations in four isolated cases. Pope [68] mentions a case of loss of taste associated with pressure on the glossopharyngeal in a patient suffering from thrombosis of the vertebral artery. That of Lehmann [59] showed ageusia, following a traumatic lesion of the seventh, eighth, ninth, and twelfth nerves. In Cassirer's [7] case the ninth, tenth, eleventh, and twelfth nerves were paralysed owing to trauma, and the lesion was accompanied by loss of taste; whilst in a most interesting case of fracture of the base of the skull, noted by Bruns [4] on the one side, the lesion implicated the whole trigeminus without any affection of taste; on the other side the paralysis of the facial was associated with complete loss of the sense of taste.

The best evidence dealing with the relationship of the fibres of taste and the trigeminus is derived from the examinations made of patients after the removal of the Gasserian ganglion. The table given below will show at a glance the condition found in all the published cases of Gasserian ganglion extirpation, in which a report on the taste was made. Krause [50] found in his six cases that taste was abolished in two, was partially affected in three, and in one was wholly unimpaired. From these positive results Krause concludes that the trigeminus contains no taste filaments, and that these are altogether derived from the glossopharyngeal. Cushing's [13 and 14] results are more conclusive evidence against the importance of the fifth. In his first series of thirteen cases, although in practically all there was either complete abolition or blunting of taste after the operation, yet in only one instance (in which only one

examination was made six days after the operation), did he fail to demonstrate complete return of this sense. Cushing's second series of cases is as interesting as his first. Five showed no impairment whatever; in one case there was marked affection at first, but considerable though not complete return later, whilst in one case the lingual had been previously divided, and so the sense of taste was necessarily absent.

In the twenty cases [1] I have examined, in only one [2] was there complete loss of taste on the side of the operation, and this loss was found to affect also the posterior third of the tongue and the palate on that side; it was then two and a quarter years since the operation. In sixteen [3] of the cases seen at varying periods of nine days to seven years after the operation practically no permanent difference in the two sides could be detected, especially when the patients had had a little training. Of these some, however, showed marked deficiency shortly after the operation, but when seen later this was no longer apparent.[4] One case,[5] indeed, was most striking and repeatedly proved that the sense of taste was better on the side from which the ganglion had been removed. In the remaining three cases [6] there was certainly less accuracy in the recognition of flavours on the side of the operation than on the other, but of two of these patients [7] only one examination of each had been made, and that within the first fortnight of convalescence. With the exception of Case 8, mentioned above, no difference was found in the perception of taste on the posterior third of the tongue or palate on either side.

An examination of Table I. given below shows that of 107 cases in which the condition of the taste has been given after the removal of the Gasserian ganglion, in forty-six

[1] Cases 1, 3, 4, 6, 8, 10, 12, 13, 14, 15, 16, 17, 19, 21, 22, 23, 24, 25, 27, 30.
[2] Case 8.
[3] Cases 1, 3, 4, 6, 10, 12, 13, 14, 16, 17, 21, 22, 23, 24, 25, 27.
[4] This was most noticeable in Case 23, who on the ninth day had absolute ageusia on the side of the operation, but two months later had completely recovered, and taste was then excellent on both sides.
[5] Case 17.
[6] Cases 15, 19, 30.
[7] Cases 19 (thirteen days after). 30 (fifteen days after).

the sense was unaffected as opposed to thirty-four,[1] in which complete ageusia was present, whilst twenty-seven suffered from some affection on the side of the operation. In Table II. are collected those cases examined by Krause, Cushing and myself, at a period of one month or more after the operation. Of the forty patients in this list, thirty-three have suffered no impairment, whilst three[2] have lost their sense of taste, the remaining four showing a varying degree of affection.

In the face of these figures it is obviously impossible any longer to consider the trigeminus as the normal channel through which taste fibres reach the brain.

There are yet two questions to be considered:—

(1) Why is there sometimes a disturbance, either temporary or permanent, in the sense of taste after removal of the Gasserian ganglion?

(2) What is the course of the taste fibres?

In answer to the first, Krause emphasises that the lesser superficial petrosal, which connects the geniculate ganglion with the glossopharyngeal, may readily be injured in stripping up the dura mater to reach the Gasserian ganglion, or it may later on be caught up in scar tissue, and, as he considers it very probable that the gustatory fibres reach the mouth by the communicating branch, this injury might explain the loss of taste in certain cases. Krause also considers it possible that the path for taste fibres may vary in different individuals. Dixon [19 and 20], who also gives these two views, states that in some cases the geniculate ganglion is separated from the middle fossa by dura mater only, and that, therefore, it is quite easy for some injury to happen to the cells of this ganglion, and so to abolish the central connections of the chorda. Cushing considers that "this temporary loss of function may possibly be occasioned by some interference with chordal transmission brought about by a mechanical or toxic disturbance due to degeneration of the N. lingualis."

[1] In many of these cases the examination was made within a week or two of the removal of the ganglion.

[2] Krause. Frau, Prof. R., six weeks; Frau, W., six months; the author, Case 8, two and a quarter years.

Whilst it is quite possible to conceive that considerable damage might occur to the chorda tympani at the geniculate ganglion, yet one would scarcely expect to find a series of cases showing marked injury to the fibres of this nerve through a lesion of the ganglion of the facial, without there being some implication also of part, at any rate, of the seventh. By Cushing's hypothesis, on the other hand, a temporary or permanent abolition of taste impulses is more easily accounted for. Sir Victor Horsley has suggested to me that the unilateral furring of the tongue often so noticeable in these patients, and generally lasting for many days after the removal of the ganglion, may to a great extent be the cause of the temporary diminution in the perception of taste.

The answering of the second question is still more difficult, and the results of histological investigations are not wholly in accord with the more recent clinical work. The latest contribution on the subject is an article by Nageotte [66], who shows that the so-called gustatory nucleus in the brain is connected with fibres from the trigeminus, the pars intermedia of the facial and the glossopharyngeal,[1] consequently he assumes that all these nerves are associated with the sense of taste. He details the case of a man who suffered from right facial paralysis and who was found at the autopsy to have a metastatic malignant tumour in the Fallopian aqueduct below the geniculate ganglion. The observations on the condition of taste having been lost, Nageotte assumes on general knowledge that ageusia was present; certain it is that the chorda tympani and facial were degenerated below the lesion; furthermore, the pars intermedia in its intrapontine course also showed complete degeneration of its fibres, and this was traced to the gustatory nucleus "situated in the prolongation of the anterior cornu of the crescent which is formed by the descending root of the fifth pair." No mention is made, however, of the condition of the intramedullary fibres of the trigeminus. From the observations on this

[1] The close connection of the fibres of the trigeminus and glossopharyngeal with the gustatory nucleus has been previously demonstrated by Ramón y Cajal (71).

case, and those made by Wallenberg [96] on a patient, who had a tumour affecting the hypoglossal and a part of the trigeminus only, accompanied by hemiatrophy and loss of taste on the back of the left side of the tongue, and in whose brain degenerated fibres were traced down to a small mass of grey matter which corresponded in position with the gustatory nucleus, Nageotte is convinced that this nucleus is for the reception of the gustatory impulses. Sapolini [78], however, has traced the connections of this bulbopontine nucleus by the pars intermedia with the chorda tympani.

Clinically, evidence has been brought forward which affords support to those who hold the view that the fibres pass by the pars intermedia, as well as to those who favour the glossopharyngeal as the path of the gustatory impulses. But including the evidence of morphological, developmental and histological observations, I am inclined to the opinion that the gustatory impulses reaching the geniculate ganglion by the lingual and chorda tympani pass thence to the brain in the pars intermedia.

Further clinical investigations and experimental work can alone solve the problem.

TABLE I.

List of Cases in which the Condition of Taste was observed after Resection of the Gasserian Ganglion.

Recorded by.	Total.	Taste unaffected.	Taste impaired.	Taste lost.
Blüher (3)	1	... —	... —	... 1
Cahen (5)	1	... —	... —	... 1
Coelho (9)	1	... 1	... —	... —
Dandridge (16)	1	... —	... 1	... —
Depage (17)	1	... —	... —	... 1[1]
Erdmann (25)	1	... —	... —	... 1
Eskridge and Rogers (26) ...	1	... —	... —	... 1
Garré (31)	1	... —	... 1	... —
Hutchinson, J., Jun. (45) ...	1	... —	... —	... 1
Knock (49)	1	... —	... 1	... —

[1] Depage says: "Le goût semble avoir disparu dans les deux tiers anterieurs de la langue du coté opéré," p. 693.

Recorded by.	Total.	Taste unaffected.	Taste impaired.	Taste lost.
Kruger (57)	1	... —	... 1	... —
Marchant et Herbet (63) ...	1	... 1	... —	... —
Monari (64)	1	... —	... —	... 1
Stewart, R. W. (84)... ...	1	... —	... —	... 1
Thomas, Lynn (87)... ...	1	... 1	... —	... —
Weeks (97)	1	... —	... 1	... —
Winslow (98)	1	... —	... —	... 1
Draudt (21)	2	... —	... 1	... 1
Friedrick (29)	2	... —	... 1[1]	... 1[2]
Rose (74 and 75)	2	... —	... 1	... 1
Thomas, H. M. (86) ...	2	... 1	... —	... 1
Keen (47 and 48)	3	... —	... 1	... 2
Maier (62)	3	... —	... 2	... 1
Pruschinin (70)	4	... —	... 3	... 1
Gowers (35)	5[3]	... —	... —	... 5
Lexer (60)	6	... —	... —	... 6
Tiffany[4] (88, 89, 90, 91) ...	6	... 4	... —	... 2
Tiffany[5] (89 and 90)... ...	10	... 4	... 6	... —
Krause (50)	6	... 1	... 3	... 2
Cushing (13 and 14) ...	19[6]	... 17	... 1	... 1
Davies[7]	20	... 16	... 3	... 1
Total	107	46	27	34[8]

[1] The first examination was made by Friedrick on the fourteenth day, and taste was found to be considerably impaired. The second examination was made by Perthes (67) three years later; taste was then found to be much impaired on both sides.

[2] The only examination was made on the twenty-ninth day. The sense of taste was found absent on the side of the operation, whilst on the other side sweet and bitter only were recognised.

[3] All these cases had been operated on at the National Hospital for the Paralysed and Epileptic, four of them by Sir Victor Horsley and one by Mr. Ballance. In Mr. Ballance's case, taste appeared to be present on both sides one week after the operation, but a fortnight later there was complete loss of taste.

[4] These are Tiffany's own cases.

[5] These are personal communications to Tiffany: Two by Abbé, one by Chambers, four by Hartley, two by Murphy, one by Richardson.

[6] Cushing gives twenty cases, but one of these is not given in this list as the lingual nerve had been previously divided.

[7] These twenty cases were operated on in University College Hospital—nineteen by Sir Victor Horsley, and one by Mr. Bucknall.

[8] In many of these cases the examination was made within a week or two of the operation, and the ageusia noticed may therefore have been only temporary.

TABLE II.

Cases examined by Krause, Cushing and Morriston Davies more than one month after the operation.

Examined by	Total.	Taste unaffected.	Taste impaired.	Taste lost.
Krause ...	5	1	2	2
Cushing ...	18	17	1	—
Davies ...	17	15	1	1
Total ...	40	33	4	3

(*b*) *Smell.*

Method.—The substances used in testing this sense were ether, ammonia, peppermint, cinnamon, valerian, and phenol. These solutions were held at some distance from the nose and gradually brought nearer; the one nostril being held firmly closed, while the patient inhaled through the other.

According to Krause [50], who agrees with Magendie, the branches of the fifth through their connections with the olfactory nerves share in the faculty of smell; whilst Cushing [13] considers this sense to be unimpaired.

I examined seventeen patients,[1] of whom fifteen[2] showed no difference in acuity of perception on the two sides; in one patient[3] the time taken to recognise any substance placed against the anæsthetic nostril was a little longer than when held to the other side of the nose, and in another case[4] there was some hesitation in the recognition of cinnamon, peppermint, ether, and ammonia on the side of the operation. Five[5] of these patients were tested both before and after the removal of the ganglion, and none of them showed any change.

I also heard from fourteen patients, whom I was unable to examine personally; of these ten stated that they could notice no difference on the two sides; three said that they were unable to smell quite so well on the side of the operation, whilst one affirmed that she could not smell at all.

[1] Cases 3, 5, 8, 10, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 30.
[2] Cases 3, 5, 10, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 30.
[3] Case 19.
[4] Case 8.
[5] Cases 21, 23, 24, 25, 26.

(*c*) *Hearing.*

Method.—Patients were tested with a watch, tuning fork, and Galton's whistle; the membrana tympani was also examined so as to note its condition, and to see if any retraction or bulging was present.

There is no evidence to show that the sense of hearing is in any way impaired after the Gasserian ganglion has been removed. Neither Krause nor Cushing found any noteworthy impairment in their cases; and in patients of this series who were tested both before and after the operation, no alteration in capacity of hearing could be discovered. The question of the paralysis of the tensor tympani will be discussed when dealing with the motor paralysis resulting from the operation, but to repeat, no change in the position of the membrane, no increase in the power of recognising the high-pitched sounds emitted with a Galton's whistle, and no deficiency in the appreciation of lower-toned notes were made out. The majority of the patients themselves acknowledge no loss of this sense when examined, though not a few complain of dulness of hearing.

(*d*) *Vision.*

Method.—The width of the palpebral fissure, the relative sizes of the pupils, and their reaction to light and accommodation, were noted. The eyes, when possible, were tested both before and after the operation; the distant and near vision were examined with and without correcting glasses, and the near point of vision was found. Finally, the fundus was examined with the ophthalmoscope.

If the eyes be examined immediately after the operation, it will be found that the pupil on the side of the operation is smaller than the other. In nearly all cases, however, this contraction has passed off by the next day, and no change can be detected afterwards. I have on several occasions had the opportunity of seeing this phenomenon in monkeys, on whom the operation of excision of the Gasserian ganglion with evulsion of the sensory root has been performed by Sir Victor Horsley. Krause was not able to note this change in

his patients, whilst Cushing [13] observed in eight of his cases a pupillary contraction which lasted for some weeks. In some of his cases also there was a slight narrowing of the palpebral fissure; this I have observed, since in almost all cases there has been a varying degree of ptosis present, owing to the anterior end of the scalp incision dividing the upper branches of the facial, and causing drooping of the eyebrow.

None of the patients have ever shown any defect in their power of accommodation subsequent to the neurectomy.

In several cases I was able to test the eyesight and near point of vision, both before and after the operation; in four[1] of these cases the examination after the operation was unhampered by neuropathic keratitis[2] or opacities of the cornea, and in none of them was any diminution of the acuteness or alteration in the near point of vision observed.

(6) Motor Distribution.

(*a*) *Muscular.*

After excision of the Gasserian ganglion and the motor root of the fifth nerve,[3] the muscles of mastication on that side are paralysed and wasted; these muscles are the temporal, the masseter, and the external and internal pterygold.[4] But it has been asserted that certain other muscles are innervated by the motor division of the trigeminus, and that these, therefore, also undergo degeneration; they are the mylohyoid and anterior belly of the digastric, the tensor tympani and the tensor palati. Both Krause [50] and Cushing [13] maintain that the wasting of the mylohyoid and

[1] Cases 21, 22, 24, 26.

[2] Dr. Hall and I hope shortly to bring out a paper on Neuropathic Keratitis, in which the bacteriological hypothesis will be especially considered.

[3] These two are nearly always removed together; but in one case in which Sir Victor Horsley had already removed one Gasserian ganglion, and in which he had to extirpate the ganglion of the other side at a later date, he endeavoured to preserve the motor root at the second operation, but was obliged to plug the foramen ovale with a portion of the temporal muscle to stop the hæmorrhage after removing the ganglion. The motor root, however, degenerated, and the patient is unable to actively close the mouth.

[4] In Case 15 the temporal muscle only appears to have atrophied, and the lower jaw is not laterally deflected when the mouth is opened.

anterior belly of the digastric is recognisable on palpating the floor of the mouth, although giving rise to no symptoms, but I have only been able to detect in two[1] out of twenty-six[2] cases that the floor of the mouth felt more flabby on the side of the operation. The supposed innervation of the tensor tympani by the fifth has been more universally discarded, as no change has been observed to follow excision of the Gasserian ganglion, either as to the tenseness of the drum or the increased power of the individual, when tested with a Galton whistle, to appreciate high-pitched sound, nor has any discrepancy in the accurate recognition of low notes been noticed. Both Krause and Cushing, however, have had one patient each who complained of a ticking sound in the ear. No cause could be found for it.

The innervation of the palatal muscles has not been so definitely established. Krause found no special alteration in the symmetry of the palatal arches. Cushing, acknowledging that the accessory branch of the vagus is at least a partial source of supply, considers that the trigeminus also contributes motor fibres. In four of his cases a marked asymmetry of the velum appeared after the operation. "The abnormal position consists," he says, "in a tilting of the uvula toward the side of the neurectomy, in a narrowing and heightening of the arch on the sound side, and with a broadening and lowering, apparently from relaxation, of the arch on the operative side" [13], this condition not being always apparent except on phonation, especially of the sound of a prolonged "eh." He further considers that the noises occasionally heard in the ear may be due to the Eustachian tube remaining closed during deglutition owing to paralysis of the tensor palati. If this is the case, it is surprising that so few of these patients suffer from diminution in their power of hearing. Gowers [33], in a patient who had paralysis of the fifth nerve, noted that the palate moved symmetrically and gave equal electrical reactions; Ferrier [28], in another case, found no difference on the two sides.

[1] Cases 21 and 26.

[2] Cases 1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30.

In only five[1] out of twenty-six[2] cases did I find any inequality of the palate; in each of these the velum was about one-eighth of an inch lower on the side of the operation, with the uvula a little inclined to the opposite side. In three patients operated on by Sir Victor Horsley, the peripheral ends of the roots of the fifth nerve were electrically stimulated, but whilst the mouth tended forcibly to close, no movement of the palatal muscles could be observed. Cushing states that in one of his cases, when the ganglion had been extirpated, stimulation of the stump of the mandibular division produced contractions and deflections of the palate.

In monkeys and dogs, when the motor root is stimulated, although no movement of the palate takes place, the back of the tongue becomes heaped up; and Beevor and Horsley [1] have proved that the motor innervation of the palate is by the vagal accessory. Vulpian [94], experimenting on dogs, has shown that no movement of the palate is produced by stimulation either of the fifth or the seventh, but only on stimulation of the spinal accessory or accessory vagus.

The balance of evidence seems to show that the fifth nerve has nothing whatever to do with the nerve supply of the palatal muscles. Two patients in this series exhibited facial paralysis on the day after the operation; in one[3] the paralysis was complete and involved equally the upper and lower segments of the face—it was still evident when the patient left the hospital on the twenty-fifth day, but was improving rapidly. In the other case[4] there was only a paresis of the whole side of the face, and when I saw the patient over three years after the operation all signs of it had disappeared. Cushing [13] observed in one of his cases, a few days after he had removed the Gasserian ganglion that there was complete inability to perform movements of the face on that side, and that apparently a Bell's palsy existed; this patient also recovered completely.

[1] Cases 3, 12, 17, 19, 27. (None of these unfortunately were examined before the operation.)
[2] Cases 1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30.
[3] Case 28.
[4] Case 6.

The partial facial paralysis which is always observed to affect the upper face must not be confounded with the condition just mentioned. The anterior extremity of the incision invariably divides some of the upper branches of the seventh nerve, and as a general result there is inability to wrinkle the forehead or frown on that side, the eyebrow droops, and consequently the upper eyelid is slightly lowered and the palpebral fissure narrowed. To avoid this, Cushing [10] has lately slightly altered the line of his skin incision and his method of approach to the skull.

Other changes which can be seen are the flaccidity of the lips, a little drooping of the corner of the mouth and a flattening of the naso-labial fold, together with occasionally a slightly less active play of the facial expressions on the side of the operation. This has been ascribed to a general loss of tone of the facial muscles; but it may be the persisting remnant of the habit of facial immobility adopted by the patient whilst suffering from the neuralgia. I have never seen the muscular twitching which, according to Krause and Cushing, occasionally occurs, although some patients complain of a "feeling of twitching" at the angle of the orbit and mouth (without such being visible). In six monkeys, who had had the left Gasserian ganglion removed, I could find no noticeable alteration in facial expression, but when eating they never filled the left buccal pouch.

Postural changes of the muscles produced by faradisation or by gentle traction on the lip or nose are not noticed by the patients, nor are they aware when the cheek becomes distended with food, and often complain that food when it is taken into the mouth appears to become lost. Hofmeister and Meyer [42] mention a case in which loss of vision occurred on the anæsthetic side; the patient did not know when the eyelids were opened or closed.

(*b*) *Vaso-motor and Secreto-motor.*

In reference to trophic changes other than those affecting the eye, Krause says that the majority of cases operated on do not, even several years after the operation, exhibit the slightest vaso-motor or trophic anomalies of the skin, nor is

there any indication of glossy skin and the like. The results of my observations are absolutely in accord with this statement and in no case of uncomplicated trigeminal neurectomy have I seen any vaso-motor or trophic disturbance. Two cases are, however, of interest in this connection. The one[1] developed, after the operation of removal of the right Gasserian ganglion, a left hemiplegia. When seen three and a half years later the right cheek looked redder, felt warmer, and sweated more than the left; the hemiplegia had then cleared up except for some weakness in the fingers. The other case was not a true instance of trigeminal neuralgia. Four years before she was admitted to the hospital she had suffered from a very severe attack of herpes over the front and upper part of the right side of the head. When she recovered from this the skin over the upper part of the head and forehead was quite white, whilst the hair in this region and the eyebrow and eyelashes all on the right side were lost. From that date she developed her neuralgia.

The secretion of sweat similarly is unaffected. The great majority of the patients exhibit no difference even when treated by the injection of pilocarpin. In one case[2] only have I noticed that the face has a persistently greasy and moist appearance on the side of the operation. In the patient[3] who had an endothelioma of the Gasserian ganglion removed, a recurrence of the growth had caused complete facial paralysis. In this case although the injection of pilocarpin produced equal bilateral sweating, the inhalation of ammonia, which was administered in order to observe the reflex secretion of tears, was followed by the appearance of sweating on the paralysed side only. The patient about this time developed Jacksonian epilepsy, and the same phenomenon was then observed after each fit.

Krause, who found considerable diminution or delay in the flow of tears in his patients, believes that the fibres which supply the lachrymal gland pass either directly through the branches of the trigeminus, or by way of the superior maxillary division, Meckel's ganglion and the great

[1] Case 5. [2] Case 26. [3] Case 18.

superficial petrosal, to the geniculate ganglion, and thence reach the gland by the upper branches of the facial nerve. The variations observed he considers due to the amount of injury done to the great superficial petrosal at the time of the operation, or the subsequent implication of that nerve in the scar produced in the process of healing between the dura mater and the bony basis of the skull. Tiffany [89] also considers that after removal of the ganglion there is no diminution of lachrymation on the same side. "In some cases no tears have been secreted when the patient has cried."[1]

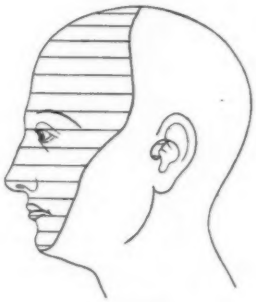


FIG. 37.

Case 14.—Two years after operation.
Shaded areas are anæsthetic.

In none of the cases of uncomplicated trigeminal neurectomy which I have personally examined have I been able to detect any difference either in the flow of tears or in the rate of onset, whether the lachrymation was natural in its origin or artificially produced by the inhalation of irritating vapours. Only in that patient[2] in whom there was associated paralysis of the facial nerve was the onset of lachrymation delayed, and the amount secreted less on the affected side.

The secretion of the salivary glands is certainly not diminished, rather there is occasionally some slight loss of

[1] P. 51.

[2] Case 18.

inhibition, as six[1] of the patients I examined or who answered my questions on this subject complained of frequent watering of the mouth on the affected side, but there was never dribbling; the rest suffered no inconvenience either from increase or diminution in the flow of saliva.

In this connection may be mentioned that case[2] in which pain recurred on the same side soon after the patient left the hospital. The attacks were quite characteristic of trigeminal neuralgia, affected the face in the area of distribution of all three branches and were associated with lachrymation, salivation and flushing. The area of anæsthesia, however, of the face,[3] mouth and palate, was typical of a case of complete resection of the Gasserian ganglion, and in addition the patient suffered from neuropathic keratitis. At a second operation some fibrous tissue was removed from the cavum meckelii, but contained no nerve structure. The irritation was probably of central origin, and the case affords additional evidence that the secreto-motor nerves to the lachrymal gland do not pass through the fifth nerve.

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[1] Case 1; 6; J. C.; E. G.; M. J.; R. H. [2] Case 14. [3] Fig. 37.

No.	Initials of patient.	Age.	Sex.	Side.	Number of days or years, after operation, of first examination.	Anæsthesia (to camel-hair brush) of face.	Pressure-touch anæsthesia; analgesia; thermal anæsthesia of face.	Anæsthesia of external auditory meatus and membrana tympani.	Anæsthesia of pa
1	C. H.	36	M.	R.	7 years	Type B	Type X. But the lower part of the forehead, the eyelids and eye, the nose and chin are sensitive to all forms of touch and pain. See fig. 14	Whole of external auditory meatus and drum anæsthetic	Anæsthesia up to including both tonsil
2	A. B.	55	M.	R.	21 days	Type A.			
3	T. D.	56	M.	R.	5 years	Type B	Area affected extremely abnormal. See fig. 18	Anæsthesia of anterior wall of meatus only	Free border of pal and area adjacent anterior faucial p sensation
4	E. H.	23	F.	R.	4 years, 5 months	Type A	Type Y	The whole of the external auditory meatus is anæsthetic. The drum retains sensation	Anæsthesia up to including both tonsil
5	A. H.	56	F.	R.	3 years, 5 months	... ...	Type X	... ...	Free border retains
6	S. A. P.	64	F.	R.	3 years, 2½ months	Type A	Type Y. See fig. 20	Anterior and superior walls of meatus alone anæsthetic	Free border of pala faucial arch and t sensation
7	J. W. H.	70	M.	L.	2 years, 9 months	Type A	Type Y	The whole of the external auditory meatus and drum are anæsthetic	Free border of p and area adjacent anterior faucial p sensation
8	A. H.	26	M.	R.	2 years, 2 months	Type B	Type X	The whole of the external auditory meatus and drum are anæsthetic	Free border of p and posterior p sensation
9	J. J.	61	F.	R.	2 years, 5 months	Type B	Type X	Anæsthesia of drum. Blunting of sensation of whole of external auditory meatus	Mouth cannot be o ciently to admit
10	W. P.	58	M.	R.	2 years, 3 months	Type C	Type X	Anterior and superior walls of meatus and antero-superior quadrant of drum anæsthetic. See fig. 28	Free border of palat tine arches and t sensation. Anæsth of mouth very abn text
11	S. C.	66	F.	R.	2 years, 2 months	Type C	Type X	External auditory meatus and drum anæsthetic, except the postero-superior angle of each	Anæsthesia up to including both tonsil
12	A. G.	42	M.	R.	2 years, 1 month	Type C	Type X	Whole meatus, except the external opening itself, anæsthetic. Drum is destroyed	Anæsthesia of fr palate including lar
13	J. G.	56	M.	R.	1 year, 9 months	Type A	Type Y	The anterior, superior and inferior walls of meatus are anæsthetic. For anæsthesia of drum see fig. 30	Free border of pala third of tonsil ar Lower part of m pillars retains sen
14	E. G.	52	M.	L.	324 days	Type B	Type X	The whole of the external auditory meatus and drum are anæsthetic	Anæsthesia up to palate and anteri
15	H. B.	67	M.	L.	1 year	Type D	Type Z	The external meatus except the roof, and the drum except the antero-superior quadrant are anæsthetic. See fig. 31	Free border of pal both pillars and sensation

MARY OF OBSERVATIONS ON THE THIRTY CASES PERSONALLY EXAMINED.

sthesia ; anal-sthesia of face.	Anæsthesia of external auditory meatus and membrana tympani.	Anæsthesia of palate.	Anæsthesia of tongue.	Taste.	Number of days or years, after operation, of final examination.	Anæsthesia (to camel-hair brush) of face.	Other changes.
ie lower part , the eyelids and chin are orms of touch ig. 14	Whole of external auditory meatus and drum anæsthetic	Anæsthesia up to free border including both pillars and tonsil	Anterior two thirds ...	Unaffected.			
emely abnor-	Anæsthesia of anterior wall of meatus only	Free border of palate, tonsil, and area adjacent to this on anterior faucial pillar retain sensation	Anterior two thirds ...	Unaffected.			
... ..	The whole of the external auditory meatus is anæsthetic. The drum retains sensation	Anæsthesia up to free border including both pillars and tonsil	Anterior two thirds ...	Unaffected.			
... ...	... ...	Free border retains sensation					
20	Anterior and superior walls of meatus alone anæsthetic	Free border of palate, posterior faucial arch and tonsil retain sensation	Anterior half	Unaffected	4 years, 4½ months	Type A	No change.
... ...	The whole of the external auditory meatus and drum are anæsthetic	Free border of palate, tonsil and area adjacent to this on anterior faucial pillar retain sensation	Anterior two thirds.				
... ...	The whole of the external auditory meatus and drum are anæsthetic	Free border of palate, tonsil and posterior pillar retain sensation	Anterior two thirds ...	Lost	2 years, 10 months	Type B	No change.
... ...	Anæsthesia of drum. Blunting of sensation of whole of external auditory meatus	Mouth cannot be opened sufficiently to admit examination	... ...	... ...	3 years, 7 months	Type B	Thermal paræsthesiæ along the upper half of the posterior margin of anæsthesia. This was the first examination of patient from this point of view. See fig. 25.
... ...	Anterior and superior walls of meatus and antero-superior quadrant of drum anæsthetic. See fig. 28	Free border of palate, both palatine arches and tonsil retain sensation. Anæsthesia of floor of mouth very abnormal. See text	Anæsthesia of middle and outer third only. See fig. 36	Unaffected.			
... ...	External auditory meatus and drum anæsthetic, except the postero-superior angle of each	Anæsthesia up to free border including both pillars and tonsil	Anterior two thirds.				
... ...	Whole meatus, except the external opening itself, anæsthetic. Drum is destroyed	Anæsthesia of free border of palate including anterior pillar	Anterior two thirds except for a strip ½ cm. broad along mesial border	Unaffected	3 years, 3 months	Type C	No change.
... ...	The anterior, superior and inferior walls of meatus are anæsthetic. For anæsthesia of drum see fig. 30	Free border of palate and upper third of tonsil are anæsthetic. Lower part of margin of both pillars retains sensation	Anterior half	Unaffected	2 years, 11 months	Type A	No change.
... ...	The whole of the external auditory meatus and drum are anæsthetic	Anæsthesia up to free border of palate and anterior pillar	Anterior half	Unaffected	1 year, 10½ months	Type B	No change.
... ...	The external meatus except the roof, and the drum except the antero-superior quadrant are anæsthetic. See fig. 31	Free border of palate including both pillars and tonsil retains sensation	None	Impaired.			

No.	Initials of patient.	Age.	Sex.	Side.	Number of days or years, after operation, of first examination.	Anæsthesia (to camel-hair brush) of face.	Pressure-touch anæsthesia; analgesia; thermal anæsthesia of face.	Anæsthesia of external auditory meatus and membrana tympani.	Anæsthesia of palate.	Anæ
16	A. D.	79	M.	R.	142 days	Type B	Type X	Whole meatus retains sensation. Antero-superior quadrant of drum anæsthetic	Anæsthesia up to free border of palate, and of anterior pillar	Anterior
17	C. R.	50	F.	L.	242 days	Type B	Type X	Anterior and superior walls of meatus anæsthetic. Drum retains sensation	Free margin of palate retains sensation, but upper border of tonsil and of posterior pillar anæsthetic	Anterior
18	G. L.	26	M.	L.	109 days	Type A. Ophthalmic division not affected	Type Y	Floor and posterior wall at commencement of meatus are sensitive; the rest together with drum is anæsthetic	Free margin together with both pillars and tonsil retain sensation	Anterior
19	M. P.	53	F.	R.	15 days	... ...	Type X	... ...	Free margin of palate, both pillars and tonsil retain sensation	Anterior
20	M. T.	55	F.	R.	16 days	Type D	Type Z	Meatus and drum retain sensation	Free margin of palate to within ½ cm. of uvula, both pillars and tonsil retain sensation	Anterior
21	C. B.	50	M.	R.	14 days	Type A	Type Y	Meatus and part of anterior half of drum anæsthetic. See fig. 29	Free margin of palate and anterior pillar anæsthetic	Anterior
22	S. C.	60	F.	L.	9 days	Type A	Type Y	Meatus and drum retain sensation	Anæsthesia up to margin of palate including anterior pillar and upper part of tonsil and posterior pillar	Anterior
23	M. H.	38	F.	L.	9 days	Type A	Posterior margin considerably in advance of anæsthetic boundary opposite tragus	Anterior, superior and inferior walls of meatus anæsthetic. Posterior three quarters of drum anæsthetic. See fig. 32	Free margin of palate, both pillars and tonsil retain sensation	Anterior
24	A. L.	46	F.	R.	9 days	Type B	Type X	Upper and anterior walls of meatus anæsthetic. Drum retains sensation	Free margin of palate, both pillars and tonsil retain sensation	Anterior
25	E. L.	66	F.	L.	10 days	Type A	Type Y	Roof of meatus and the whole drum retain sensation	Anæsthesia up to free margin of palate including anterior pillar	Anterior
26	E. B.	47	F.	R.	24 days	Type A	Type Y	Posterior wall of the meatus and the whole drum retain their sensation	Free margin of palate, both pillars and tonsil retain sensation	Anterior
27	T. W.	49	M.	L.	12 days	Type A	Posterior margin considerably in advance of anæsthetic boundary, and resembling Type X	Meatus and drum anæsthetic	Free margin of palate, both pillars and tonsil retain sensation	Anterior
28	F. C.	52	F.	L.	15 days	Type A	Type Y	Meatus and drum retain sensation	Anæsthesia up to free border of palate including anterior pillar	Anterio
29	W. H. C.	64	M.	L.	12 days	Type A	Posterior margin some way in advance of anæsthetic boundary	... ...	Anæsthesia up to free border of palate including anterior pillar	Anterio
30	L. D.	33	F.	R.	12 days	Type A	Opposite tragus posterior margin in advance of anæsthetic boundary. Area between the two posterior borders shows thermal paræsthesia. See fig. 22	The antero-superior wall only of the first centimetre; the whole of the rest of the meatus, and the drum are anæsthetic	Free margin of palate, both pillars and tonsil anæsthetic	Anterio

Pressure-touch anæsthesia; analgesia; thermal anæsthesia of face.	Anæsthesia of external auditory meatus and membrana tympani.	Anæsthesia of palate.	Anæsthesia of tongue	Taste.	Number of days or years, after operation, of final examination.	Anæsthesia (to camel-hair brush) of face.	Other changes.
Type X	Whole meatus retains sensation. Antero-superior quadrant of drum anæsthetic	Anæsthesia up to free border of palate, and of anterior pillar	Anterior two thirds ...	Unaffected	2 years	Type B	Thermal paræsthesiæ extending between the posterior border of an anæsthesia of type C and one of type A. See fig. 26. Patient not examined for this when first seen.
Type X	Anterior and superior walls of meatus anæsthetic. Drum retains sensation	Free margin of palate retains sensation, but upper border of tonsil and of posterior pillar anæsthetic	Anterior two thirds ...	Unaffected	1 year, 11 months	Type B	Posterior margin of anæsthetic zone shows thermal paræsthesiæ. Patient not examined for this when first seen.
Type Y	Floor and posterior wall at commencement of meatus are sensitive; the rest together with drum is anæsthetic	Free margin together with both pillars and tonsil retain sensation	Anterior half.				
Type X	... ...	Free margin of palate, both pillars and tonsil retain sensation	Anterior two thirds ...	Impaired.			
Type Z	Meatus and drum retain sensation	Free margin of palate to within ½ cm. of uvula, both pillars and tonsil retain sensation	Anterior two thirds.				
Type Y	Meatus and part of anterior half of drum anæsthetic. See fig. 29	Free margin of palate and anterior pillar anæsthetic	Anterior two thirds ...	Unaffected	55 days	Type B	Type X. No other change.
Type Y	Meatus and drum retain sensation	Anæsthesia up to margin of palate including anterior pillar and upper part of tonsil and posterior pillar	Anterior two thirds ...	Unaffected	172 days	Type C	Type X. No other change.
Posterior margin considerably in advance of anæsthetic boundary opposite tragus	Anterior, superior and inferior walls of meatus anæsthetic. Posterior three quarters of drum anæsthetic. See fig. 32	Free margin of palate, both pillars and tonsil retain sensation	Anterior two thirds ...	Unaffected	190 days	Type C	Type X. No other change.
Type X	Upper and anterior walls of meatus anæsthetic. Drum retains sensation	Free margin of palate, both pillars and tonsil retain sensation	Anterior half	Unaffected.			
Type Y	Roof of meatus and the whole drum retain sensation	Anæsthesia up to free margin of palate including anterior pillar	Anterior half	Unaffected	1 year, 7½ months	Type B	Type X. Thermal anæsthesia corresponding to type A.
Type Y	Posterior wall of the meatus and the whole drum retain their sensation	Free margin of palate, both pillars and tonsil retain sensation	Anterior two thirds ...	... ...	1 year, 2½ months	Type B	Type X. No other change.
Posterior margin considerably in advance of anæsthetic boundary, and resembling Type X	Meatus and drum anæsthetic	Free margin of palate, both pillars and tonsil retain sensation	Anterior two thirds ...	Unaffected	315 days	Type B	Type X, but slightly constricted. Area of thermal paræsthesiæ extending back from this to tragus. See fig. 17.
Type Y	Meatus and drum retain sensation	Anæsthesia up to free border of palate including anterior pillar	Anterior two thirds.				
Posterior margin some way in advance of anæsthetic boundary	... ...	Anæsthesia up to free border of palate including anterior pillar	Anterior two thirds.				
Opposite tragus posterior margin in advance of anæsthetic boundary. Area between the two posterior borders shows thermal paræsthesia. See fig. 22	The antero-superior wall only of the first centimetre; the whole of the rest of the meatus, and the drum are anæsthetic	Free margin of palate, both pillars and tonsil anæsthetic	Anterior two thirds ...	Impaired	143 days	Type C	Type X. No other change except that thermal paræsthesiæ, present at first, have disappeared.

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Review.

Studies in Clinical Psychiatry. By LEWIS C. BRUCE, M.D. Pp. 246. London: Macmillan & Co., 1906.

ONE cannot help wishing that the phrase which appears in the preface "the views advanced and the evidence which is believed to support them are admittedly incomplete, but so much material had accumulated on my hands that I found it expedient to crystallise my views in print," had been repeated at the top of every page. Or possibly it would have been wiser for the author to have been content to have recorded as preliminary experiments the large number of valuable observations he has made, and postponed the drawing of conclusions until he had had opportunity of corroborating them after consultation with a critical friend.

Bruce is convinced of the truth of the theory he propounds, and all must recognise that such conviction adds greatly to the difficulty of setting out evidence in an impartial manner, however trustworthy that evidence; this difficulty has not been completely surmounted.

The main object of the book is to prove that certain forms of insanity are due to bacterial invasion, and it is suggested that in some cases the micro-organisms are present in the blood stream.

The chief lines of investigation may be classified as follows:—

(1) The examination of white cells in the blood.

(2) The isolation of micro-organisms from the blood, and the effects of the injection of cultures into animals.

(3) The agglutinative power of the sera of certain patients on certain cocci.

A very large number of estimations of the number and kinds of white cells in the blood have been recorded, and the results divided into six classes; with only three of these need we deal:—

(*a*) Leucocyte counts in "non-toxic" insanities, in which it was a rare thing to find more than 10,000 leucocytes per cubic millimetre.

(*b*) Leucocyte counts in insanities due to "metabolic toxæmia." The highest number recorded was 12,000.

(*c*) Leucocyte counts in insanities due to "bacterial toxæmia." In this condition excitement seems to have been a constant feature, and the leucocytosis frequently reached 40,000.

Bruce ought to have decided whether he wished to record the condition of the blood in insanity due to bacterial toxæmia, or whether hyperleucocytosis was to be used as evidence that some forms of insanity are of bacterial origin. It is certain that the dual use of the observations is not admissible. Let us assume that it is used as an argument that certain forms of insanity are of bacterial origin, and see how far it is a trustworthy method of deciding the question.

It is well known that the invasion of many bacteria such as pneumococci, streptococci, staphylococci, and many others, lead to a hyperleucocytosis; but it must be remembered that, on the other hand, the bacillus of influenza and the typhoid bacillus usually cause a hypoleucocytosis, whilst the tubercle bacillus may be demonstrated in the blood of patients with a normal number of white cells per cubic millimetre.

The next question is whether many substances which are not the result of bacterial activity, will not also lead to a hyperleucocytosis upon their introduction into the body. In answer to this, we may say that the majority of substances will cause some increase in the number of leucocytes in the blood when injected either into the blood stream or into the subcutaneous tissue. Even simple bodies, such as normal salt solution, when poured into the peritoneal cavity, will bring this about in a marked degree.

One is therefore forced to the conclusion that hyperleucocytosis by itself is not evidence of bacterial invasion; it may be due to the production of some abnormal body as the result of an altered metabolism, or to the passage of substances from the alimentary tract into the blood, and these may or may not be produced by bacteria.

Bruce found that patients suffering from general paralysis might one day have a leucocyte count of 10,000, and at the same time on the next day 30,000; this alone would make one pause before basing a theory upon leucocytosis.

The variety of the leucocytosis assists but little; for although it is true that in the majority of infections with virulent organisms when a hyperleucocytosis occurs, it is as a rule of the polynuclear type, this is not invariably the case. Eosinophilia arises in a multitude of conditions, and but few hæmatologists would at the present day draw any conclusion from so slight a degree as 8 per cent. of eosinophile cells.

In order to be able to estimate the value of the results based upon bacterial examination of the blood, full details are necessary; for it is only after studying them that one is able to determine the trustworthiness of the technique employed.

For the last two years Bruce has examined the blood of every case of acute mania which has come under his care; unfortunately he omits to record how many this is. In two cases only were bacteria isolated, but one may infer that one examination of the blood was made in each case, for he writes, "the method adopted was to run 3, 4, or 5 cc. of blood into 200 cc. of sterile broth, by means of an exploring needle passed into a prominent vein in the forearm. Seven of the flasks were sterile, two were accidentally contaminated; but one, obtained from a case which had passed into a typhoid state, presented a pure culture of a short streptococcus." The patient recovered for a time, and therefore this was not due to an end infection.

Contamination of 20 per cent. of flasks shows that the technique was not all that could be desired, and it is within the limits of possibility that the short streptococcus which was grown in pure culture did not take its origin from the blood introduced into the flask.

When conducting a research, it is customary to inoculate quite a large number of tubes containing different kinds of media, and if all be found sterile upon the first occasion, another series is inoculated with blood and the process repeated at least a third time before drawing the conclusion that the blood is sterile for the usual media.

The method recorded is only suitable when one wishes to isolate the bacillus from the blood of a patient suffering from a known infection. Bruce recognises the weakness of the proof, and brings additional evidence from experiments with agglutinines.

A somewhat different form of streptococcus was obtained from the blood of a patient, who was suffering from acute mania with confusion. The effects of injections of these micro-organisms into animals varied with the age of the animal. Injections of 1 cc. of a broth culture into the peritoneum of rabbits two or three days old retarded growth and development, and occasionally produced paralysis of the hind legs, bladder, and rectum. These signs are not peculiar to the streptococcus under discussion.

The number of different organisms which have been isolated from the blood and other tissues of patients suffering from insanity increases daily, and leads one to believe that no specific organism, if it exist, has been found and recognised. It behoves us to be

cautious in ascribing disease to a bacterium because it happens to be present, for the history of bacteriology is full of events in which theories based upon insufficient evidence have been accepted, and the growth of knowledge thus retarded.

Bruce's observations on agglutinines may be divided into two series conducted with two varieties of cocci. A streptococcus derived from the blood of a patient suffering from mania and a staphylococcus obtained from the bone marrow of a patient who had died in a typhoid state. He found that the serum of patients suffering from acute mania agglutinated the streptococcus in dilutions of 1 to 30, whilst that from normal individuals failed to do so in dilutions of 1 to 10. Although this difference is not striking, nevertheless, if constant it is suggestive of the streptococcus being present in some part of the body of the patients suffering from mania, but not necessarily in the blood stream.

One would like to know whether the control observations were carried out at the same time with the same culture, or on another day with subcultures, or possibly an older culture. Whether the serum was of the same standing, *i.e.*, collected at the same time from patients and healthy individuals, and whether it had been allowed to stand with the clot for a definite period only.

In addition to these points one wants assuring that the patients had not been injected with any kind of serum; for it has been recognised that occasionally an injection of an antitoxic serum will lead to the serum of a patient agglutinating the typhoid bacillus, even when that patient has not, and never has had, typhoid fever.

No doubt subsequent editions of the book will contain this essential information.

It is difficult to understand why Bruce thought fit to record his experiments on the attempt to produce hæmolysins in patients, for he is quite awake to the fact that they are valueless, for he has not made any controls with similar quantities upon healthy individuals.

Bruce sums up the evidence in favour of general paralysis of the insane being of bacterial origin in the following words:—

"The temperature is characteristic of a toxæmia; in the first stage of general paralysis, uncomplicated by acute mental disturbance, the temperature is irregular, the evening temperature often rising to 99° or 100°, and falling in the morning. In the second stage the febrile temperature is recurrent every two, three, or four weeks, and the last stage is very irregular. If the general paralysis be complicated by acute mental disease,

the temperature is not characteristic; it is apt to be higher than the first stage and subnormal in the second, more particularly if the mental complication has been acute excitement. Secondly, disturbances of the alimentary tract, which often appear early in the disease, and are characterised by attacks of diarrhœa, jaundice, biliousness, and capricious appetite, are suggestive of subacute toxæmia. Thirdly, the leucocytosis is irregular in the first stage with a high polynuclear percentage, regularly recurrent in the second, corresponding to the rise in temperature, very irregular in the last stage and characterised by a low polynuclear percentage. It is thus typical of a bacterial infection which gradually exhausts the leucocyte-producing power of the bone marrow. The blood serum also is deficient in some substance present in the serum of healthy persons, which is capable of agglutinating certain strains of *Staphylococcus aureus pyogenes*. It occasionally contains an agglutinine to the diphtheroid organism of Ford Robertson, McRae, and Jeffrey. Further, the frequency with which general paralytics become affected with tubercle indicates a low bacterial resistance power. Lastly, the steady advance of the physical symptoms, the tremor of the muscles, the frequency with which the sensory and motor nerves are implicated early in the disease, all point to some diffusible toxin carried by the blood stream which is capable of attacking the nervous system, either centrally or at the periphery.

"Experimental evidence consists in the fact that the serum of cases of general paralysis in a state of remission when injected into an early progressive case, arrests the disease. I have seen this occur three or four times within the last five years, and three of these patients are now earning their own livelihood. The result can only be explained on the supposition that the sera of some cases whilst in a state of remission contain an immune body. Further, severe attacks of erysipelas, carbuncle, pneumonia, and abscesses induced by subcutaneous injection of terebene will often arrest indefinitely the progress of the physical symptoms. I actively immunised one patient to the diphtheroid organism of Ford Robertson, McRae, and Jeffrey, and completely arrested the progress of the disease, the patient being finally discharged, but died six months later from phthisis."

The evidence is far from conclusive. The oscillation of temperature is somewhat greater than that recorded in perfectly healthy individuals, but is not so great as that which usually accompanies bacterial invasion, and one must remember that undoubtedly emotion may have an effect upon temperature, as is so frequently

shown by the rise in temperature following the visiting day at a hospital. Many have observed a so-called hysterical temperature which may rise every evening to 101° F., and fall in the morning to 98° F., a variation of three, and occasionally of four, degrees, which will continue for weeks, or even months. The temperature in this form of disease may become perfectly normal upon the visit of a friend or upon the patient altering her environment, It seems very unlikely that this could be attributed to any bacterial condition, and one is at a loss to see why a rise in temperature in mental diseases should be placed upon a different foundation.

Disturbances of the alimentary tract, such as diarrhœa and capricious appetite, may be associated more closely with emotional disturbances than any other, and the fact that a certain percentage of cases of diarrhœa follows the infection of the alimentary tract with a definite micro-organism does not permit of the conclusion that diarrhœa is evidence of the introduction of a pathogenic micro-organism.

The argument that general paralytics become affected with tubercle indicates a low bacterial resistance, and, therefore, is evidence that the patient is already infected with the micro-organism, is not easy to follow. We know that many diseases such as myxœdema and diabetes mellitus apparently prepare the soil for the tubercle bacillus, but I doubt whether any one at the present day would venture to assert that either of these diseases is of bacterial origin.

The experimental evidence is of more value, and we congratulate the author in finding time and energy to carry out experimental work in a branch of medicine which, until recently has eschewed the subject. We hope that experiment after experiment will be conducted and that in time results will have accumulated which will permit of conclusions being drawn, conclusions based upon so much evidence that the sceptic will be convinced. But at present this is far from being the case, and the doubter might suggest that those cases of general paralysis of the insane which have improved or completely recovered upon injection of serum taken from patients during the remission stage of general paralysis of the insane, have not in truth been cases of that disease. But even if this be the case, it would need a series of experiments in which fresh human serum taken from normal people had been injected without avail, before one could conclude that there was anything curative in the serum of the remission case; for it is within the limits of possibility that the introduction of a complement is all that is neces-

sary, and it is not due to any immune body. It is by rigid experiment only that such hypotheses can be proved and rendered of permanent value in the elucidation of the problems of mental disease.

OTTO GRÜNBAUM.

PUBLICATIONS RECENTLY RECEIVED.

[*Notes on a book under this heading do not preclude a subsequent review.*]

Les Atrophies Croisées du Cervelet. Par Dr. RENÉ CORNÉLIUS. Pp. 128. Paris: Jules Rousset, 1907.

A study from the laboratory of Professor Dejerine of a case of crossed atrophy of the cerebrum and cerebellum. The author believes that crossed atrophy certainly occurs, and that it is not explained by the hypothesis of two coincident lesions, but is a special instance of transneural atrophy. This appears to be due not to functional inactivity, but to an arrest of development, and the process is transmitted to the cerebellar hemisphere by the middle cerebellar peduncle, and to a less degree by the superior peduncle.

Le Paralysie de la branche externe du Spinal dans le Tabes. Par Mdlle. ANNA ANDAKOFF. Pp. 108. Paris: Jules Rousset, 1906.

A detailed and careful study of a case of paralysis of the spinal accessory in a case of tabes. To this the author has added a complete bibliography, and an abstract of previously described cases. A most valuable pamphlet.

Ueber die Untersuchung des gesunden und kranken Gehirnes mittels der Wage. Von Dr. MARTIN REICHARDT. Pp. 101. Jena: Gustav Fischer, 1906.

This is the first half of a series of observations on the weight of normal and abnormal brains. It is planned on a large scale, and, when complete, will be a valuable reference work.

Untersuchungen über die Aetiologie der Manie, der periodischen Manie und des zirkulären Irreseins. Von Dr. GIOVANNI SAIZ. Pp. 220. Berlin: S. Karger, 1907.

This is a study of all the cases of periodical mania and circular insanity, which were admitted to the Charité in Berlin from 1895 to 1906. The cases are arranged according to age, sex, occupation, &c., and every possible etiological factor is considered. Useful for reference, this work does not lend itself to a summary.

Untersuchungen über Muskelzustände. Von Professor RIEGER. Pp. 56. Jena: Gustav Fischer, 1906.

The author puts forward the idea that living muscles exert a kind of brake-power against sudden movements, which cannot be explained by the mechanics of elastic bodies. The pamphlet is printed in an extraordinary manner, with a profusion of headings in the text.

Leitfaden zur Psychiatrischen Klinik. Von Dr. M. REICHARDT. Pp. 211. Jena: Gustav Fischer, 1907.

This is a handbook for the senior student in Germany when he reaches the study of insanity. It is written too much in the style of the manuals with which we have long been familiar in England. It cannot be recommended to the expert neurologist.

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EDITOR.